D5.3 INTEGRATION AND PRELIMINARY ASSESSMENT OF THE PASSION COMPONENTS

Project title	**Photonics technologies for ProgrAmmable transmission and switching modular systems based on Scalable Spectrum/space aggregation for future agile high capacity metrO Networks**
Project acronym	**PASSION**
Grant number	**780326**
Funding scheme	**Research and Innovation Action - RIA**
Project call	**H2020-ICT-30-2017 Photonics KET 2017 Scope i. Application driven core photonic technology developments**
Work Package	**WP5**
Lead Partner	**POLIMI**
Contributing Partner(s)	**SMO, TUE, VTT, EFP, CTTC, ETRI, NICT**
Nature	**R**
Dissemination level	**PU (Public)**
Contractual delivery date	**31/03/2021**
Actual delivery date	**31/05/2021**
Version	**1.0**

History of changes

Version	Date	Comments	Main Authors
0.1		Introduction, TOC	POLIMI
0.2		Contributions	VTT, SMO, TUE, CTTC, ETRI, EFP, POLIMI
0.3		Merging of contributions	POLIMI
0.4		Quality review	B. Puttnam (NICT)
1.0		Final version	POLIMI

Disclaimer

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 780326.

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EXECUTIVE SUMMARY

This deliverable describes the assessment and integration of the various PASSION technological developments, carried out in PASSION WP3 and WP4.

In particular, three fundamental building blocks constitute the innovative PASSION technological platform supporting the future sustainable high-capacity metro network:

- the TX module based on 50-Gb/s DMT directly -modulated InP VCSEL, enabling multi-Tb/s transmission;
- the switching/aggregation node, equipped with different photonic functional components, depending on the featured hierarchical levels and handling the added and dropped traffic in both space and spectrum dimensions;
- the coherent module, allowing to target distances of hundreds of km, typical of the metro network.

Proof-of-concept experiments are reported to show the functional feature and the performance of the single PASSION components/devices constituting the blocks described above, tested in selected reference setups prepared by each individual partner in their labs. Also the integration of the components/devices by means of suitable evaluation boards is considered, to appropriately combine them, where possible, via commonly agreed interfaces. The lab-trials envisioned for the final demonstration of the capabilities of PASSION approach, performing also network-oriented experiments, are instead described in WP5 deliverable D5.4.

Starting from the TX module, experimentation done at POLIMI lab, supported by suitable simulations demonstrates the VCSEL-based transmission beyond 50 Gb/s per wavelength (PASSION target) over 100 km uncompensated SMF, also in case of dense WDM multi-channel propagation (with 25 GHz spacing as in case of the fully-equipped PASSION TX super-module). Moreover, the integration of the 40-VCSEL TX module, realized by VTT and targeting up to 2-Tb/s capacity, in a real industrial board is described in detail, following the standard industrial process used for SMO products.

The experimental assessment of the components realized for the development of the switching node is then reported. Different types of components, such as the wavelength blocker, the wavelength selective switch and the multi-cast switch have been realized and tested in detail in TUE testbed. Also the impact of the SOA on the DMT-modulated PASSION signal due to the switching node crossing is carefully analysed by POLIMI by experimentation. Moreover, the operation of the 16x16 matrix switch operating as photonic space matrix switch, realized by ETRI and based on the polymer optical waveguide of CHEM, is described, together with its packaging and integration on a PCB board. The 16x16 switch matrix was also integrated and tested in the CTTC ADRENALINE testbed, enabling spatial switching within the developed experimental set-up at data plane level.

Finally, the coherent module designed to be compatible with a flexible infrastructure, being based on programmable and modular systems, is assessed by EFP with its integration in an appropriate test board.

1 INTRODUCTION

PASSION has designed and realized an innovative technological platform supporting the challenging requirements of the future sustainable high-capacity agile metropolitan area network (MAN). This technological platform is based on three fundamental building blocks:

- an innovative modular transmitter (TX) able to assure multi-Tb/s capacity per photonic integrated circuit (PIC), based on the exploitation of long-wavelength high-bandwidth vertical cavity surface emitting laser (VCSEL) sources, directly modulated with discrete multitone (DMT) modulation, targeting 50 Gb/s rate per VCSEL;
- the switching/aggregation node, equipped with different photonic functional components, depending on their operation at the featured hierarchical levels and handling the added and dropped traffic in both space and spectrum dimensions;
- the coherent receiver (CRX), allowing to target distances of hundreds of km, typical of the metro network.

The combination of the TX module and the multi-channel CRX allows to realize a compact and cost-effective sliceable bandwidth and bitrate variable transceiver (S-BVT) able to adaptively load/manipulate the spectrum, enabling tens of Tb/s capacity per link exploiting multiple dimensions including the spectrum, the polarization and the space.

In this deliverable we describe the assessment and integration of the various PASSION technological developments, carried out in PASSION WP3 and WP4, allowing the realization and the operation of the blocks described above. Proof-of-concept experiments are reported to show the functional features and the performance of the single PASSION components/devices, tested in selected reference setups prepared by each individual partner in their labs. Also the integration of the components/devices by means suitable evaluation boards is considered, to appropriately combine them, where possible, via commonly agreed interfaces. Moreover, the appendix provides technical details of the reported SMO TX module evaluation board.

2 PASSION TRANSMITTER ASSESSMENT AND INTEGRATION

2.1 VCSEL-BASED TX MODULE

The well-proven 3-μm SOI photonic integration platform developed in VTT has been used to achieve the heterogeneous integration of multiple InP VCSELs provided by VERTILAS on the same Silicon-on-insulator (SOI) PIC, together with a 1:40 Arrayed Waveguide Grating (AWG) necessary to combine the VCSEL emissions in the same output fibre. This silicon-photonic (SiPh) PIC constitutes the multi-Tb/s VCSEL-based TX module described in detail in the deliverable D3.6 and D3.7, and visible in Figure 1. Starting from this TX module, it is possible to design and realize the innovative S-BVT proposed in PASSION. The integrated InP VCSELs emit in the C band, with dense WDM spacing of 100 GHz. 50-Gb/s rate has to be guaranteed per state of polarization (SoP) per each VCSEL thanks to the exploitation of DMT as multicarrier modulation format, in order to target an aggregated capacity per TX module of up to 2 Tb/s. The dimension of the optical TX PIC is 2 cm x 2 cm, corresponding to a total aggregated transmitted rate of 2 Tb/s.

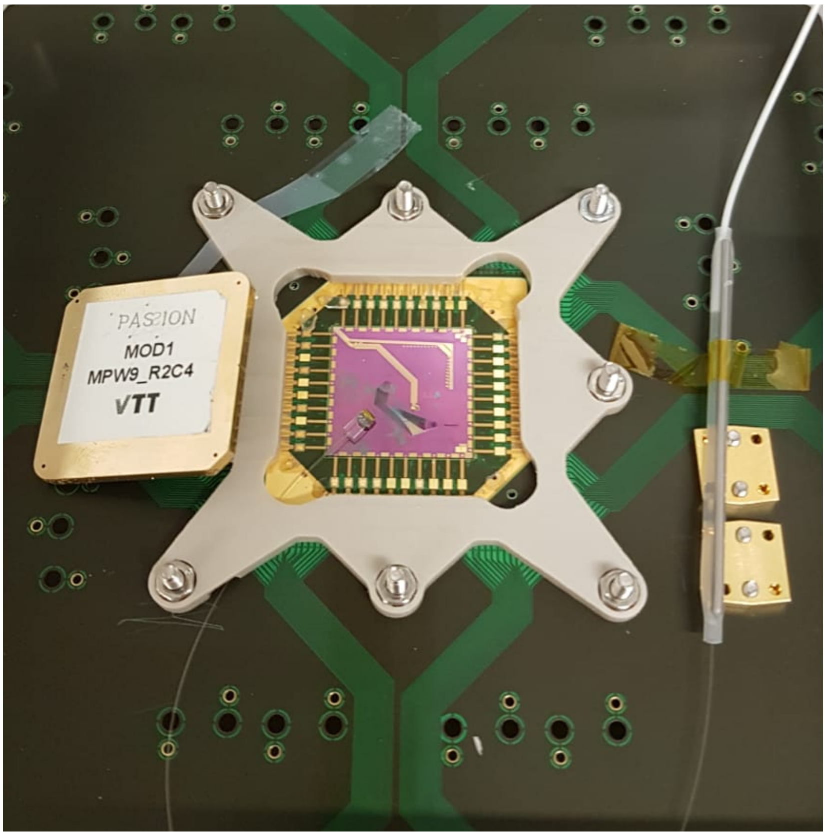


Figure 1 - VCSEL-based TX module fully packaged with LGA interposer, realized by VTT.

To assure an accurate electrical, thermal and opto-mechanical interconnection in the TX module PIC, a single electrical interposer based on a 8 layers 600 μm thick, ENEPIG-finished, Panasonic Megtron7 substrate, is employed. The necessary VCSEL drivers, provided by IDT, characterized by a linear response are flip-chip bonded onto a suitable land-grid array (LGA) interposer designed to provide interconnection and thermal decoupling capabilities to the Si-PIC, realizing a very compact, thermally efficient packaging solution.

Starting from the TX module described above, constituted by 40 100-GHz spaced DMT-modulated VCSELs, a super-module TX enabling up to 8 Tb/s total aggregated capacity can be assembled. In particular, a modular approach is adopted: just identical modules, such as the described one, can be designed and developed. The 40 emitted wavelengths from the VCSELs in each module can be fine-tuned in a range of 0-75 GHz through the VCSEL bias current and stabilized by a temperature cooler. Combining 4 of such a module, the full 160-channels TX super-module is obtained, characterized by 25-GHz granularity. The exploited modularity offers the ability to fabricate and stock only one TX module type and to use the identical 40-VCSEL modules to build the full 160-channel TX super-module. Thanks to polarization-division multiplexing (PDM), 16-Tb/s total capacity can be also achieved in a fully equipped PASSION TX super-module.

2.2 TX TECHNOLOGY ASSESSMENT

The VCSEL-based technology of the PASSION TX module has been assessed by an experimental analysis realized in POLIMI lab, supported by suitable simulations. In particular, for the transmission performance evaluation, we employed the experimental setup shown in Fig. 2, allowing to test propagation impairments in combination with coherent detection, in an amplified multi-span uncompensated reach, also in presence of multichannel propagation down to 25 GHz spacing, characteristic of the fully equipped PASSION VCSEL-based TX super-module, targeting 8-Tb/s capacity, by exploiting the combination of the outputs of four interleaved 2-Tb/s TX modules.

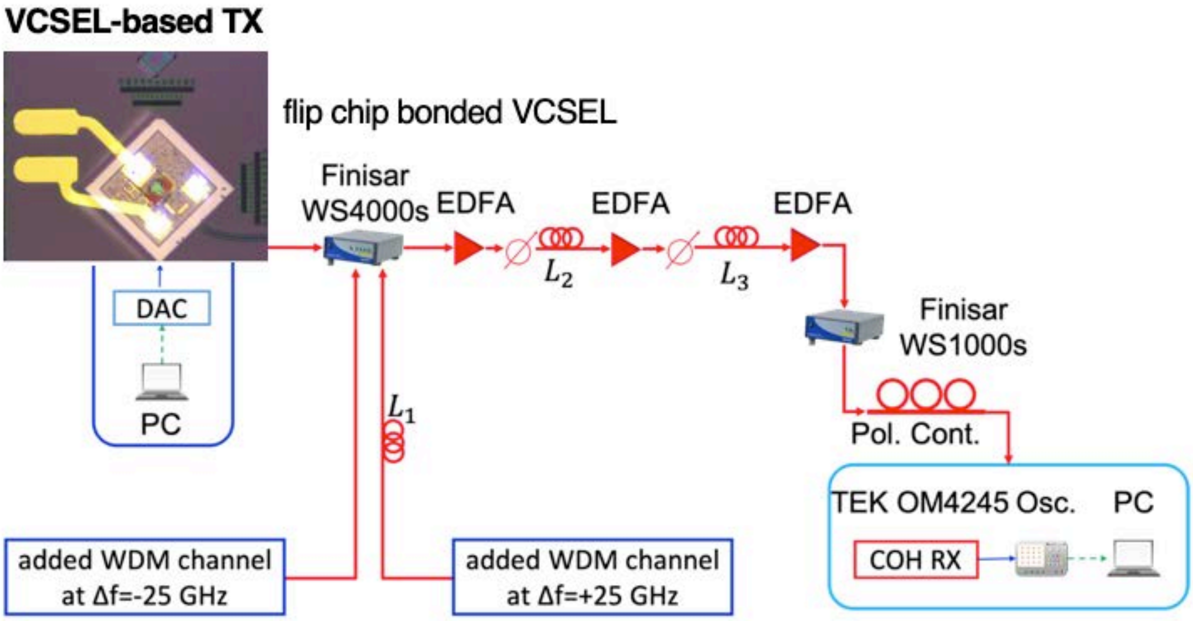


Figure 2. Experimental setup for TX technological assessment.

One VERT VCSEL is considered to assess the performance of the PASSION module, with directly modulation through a DMT signal generated by a MICRAM 100-GS/s digital-to-analog converter (DAC10002) with 35-GHz electrical bandwidth and 6 bits vertical resolution. The DMT signal is calculated by Matlab® and is composed of 256 sub-carriers in 20-GHz range; a cyclic prefix (CP) of about 2.1% of the symbol length is added. The VCSEL emitting wavelength is 1533.5 nm, while its measured linewidth is about 5 MHz. The bias current is set at 9 mA, while the modulation depth is fixed at 8 mA in order to limit the frequency chirp insurgence and reduce the penalty due to single sideband (SSB) filtering.

The TX VCSEL has been wire-bonded to a single-channel IDT driver HXT14100, which provides both the bias and the modulation currents and that can be piloted by the I^2C interface described in WP3 deliverables. A Finisar Waveshaper 4000s, which mimics the transfer function of a 25-GHz standard Wavelength Selective Switch (WSS) further performs the SSB filtering operation thanks to 8-GHz detuning with respect to the VCSEL modulated spectrum. Moreover, it acts as a 25-GHz multiplexer, adding other two optical channels with 25 GHz frequency difference with respect to the central channel. The adjacent channels are generated by modulating two 100-kHz tunable lasers by two Mach-Zehnder intensity modulators with 25-GHz bandwidth and by tuning them at ± 25 GHz from the VCSEL wavelength. The electrical DMT signals of the adjacent channels are generated by a second DAC (DAC10002) and, in order to decorrelate the patterns of the adjacent channels, a suitable 3-km long standard single-mode fiber (SSMF) spool has been used (indicated as L_1 in Fig.

2). The adjacent channels undergo SSB filtering passing through the WS4000s multiplexer. The presence of adjacent wavelength-division multiplexed (WDM) channels at 25-GHz spacing allows to analyze the case of the PASSION TX super-module.

The generated single-polarization optical signal is then amplified by an Erbium-doped fiber amplifier (EDFA) and propagates in two SSMF spools (indicated as L_2 and L_3 in Figure 2, corresponding to 50 km and 54.5 km, respectively) with different launch powers. After around 100-km SSMF propagation, the central channel is selected by a Finisar WS1000s programmable filter, which mimics the same transfer function of the multiplexer. Then, the signal is detected by the CRX. A Tektronix CRX OM4245 with 45-GHz bandwidth is in particular employed for this kind of assessment. The local oscillator (LO) is a tunable 100-kHz laser with +14.5 dBm optical power. The in-phase/quadrature (I/Q) signals are acquired by a Tektronix real-time oscilloscope with 8-bits vertical resolution, 100-GS/s and 33-GHz electrical bandwidth respectively. Optimal bit and power loadings (BL/PL) using Chow's algorithm are applied to adaptively assign the appropriate bit order at each subcarrier during the mapping procedure. This strategy enables to finely tailor the spectrum with a granularity of tens of MHz, depending on the number of adopted DMT subcarriers, allowing also MAN functionalities such as multi-flow generation, slice-ability, adaptability to traffic and reach. For example, in case of using 256 subcarriers occupying 20-GHz bandwidth, the resulting granularity is about 78 MHz.

The performance of the system is evaluated in terms of capacity achievable for a target bit error rate (BER) of $4.62 \cdot 10^{-3}$ (consistent with the use of a 7% overhead hard-decision forward error correction – HD FEC). The employment of non-linear (NL) Volterra Equalization (VE) is optionally assumed to compensate for the NL impairments induced during the fiber propagation and for the distortions introduced by the directly-modulated (DM) VCSEL source, the RF commercial driver tailored for pulse amplitude modulation (PAM), and all the other electrical devices and components employed at the TX and the receiver (RX) sides.

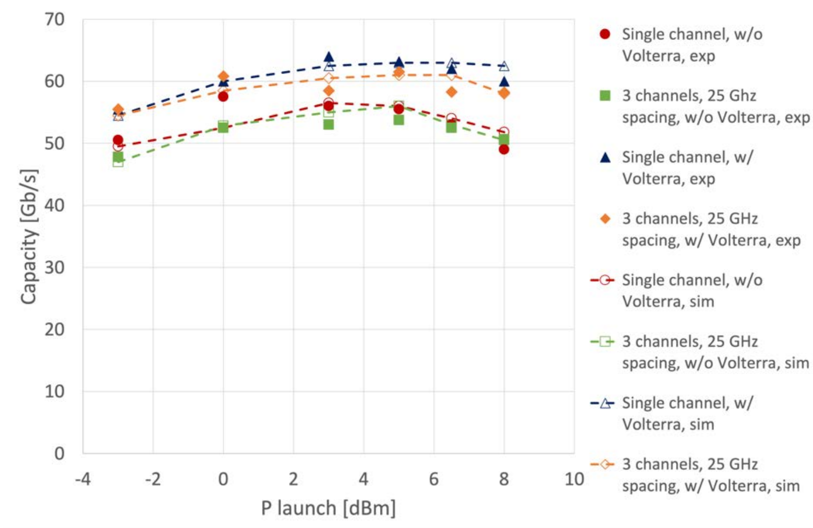
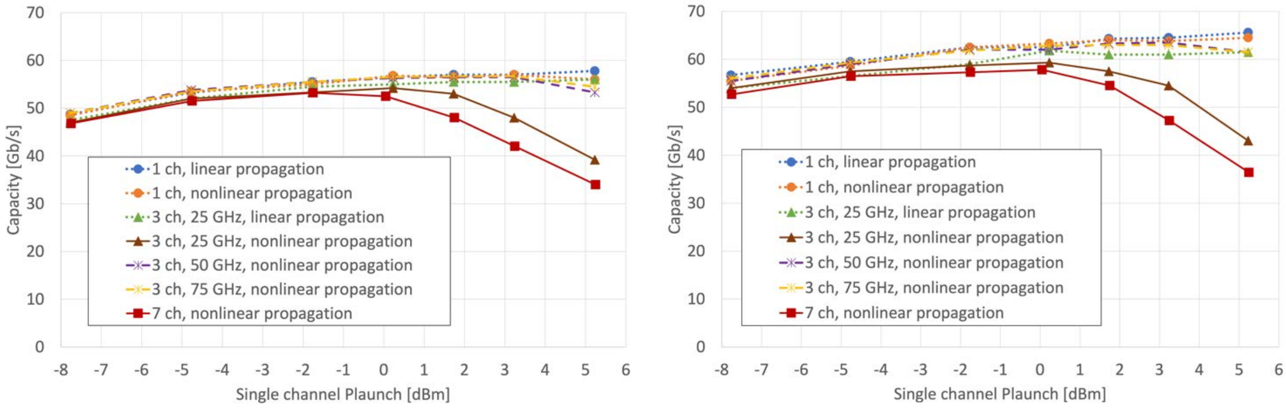


Figure 3. Experimental results for single channel and multichannel transmissions on 100-km SSMF (full marks). Numerical model in the same conditions (empty marks, dashed lines).

The capacities achieved after 100-km SSMF propagation in function of the total optical launch power are reported in Figure 3 in case of single-channel and multichannel transmissions (full marks). The evolution of the capacity in function of the launch power follows the standard parabolic shape determined by the presence of NL impairments. In particular, the optimal launch power in case of single-channel transmission (red full circles) is close to 3 dBm, while in case of multichannel propagation (green full squares) it is 5 dBm, corresponding to a power per channel around 0 dBm. The optimal condition is obtained for the same optical powers also when exploiting the VE (blue triangles and orange diamonds), evidencing that even with NL equalization the channel performance is more affected by the cross-phase modulation (XPM) presence. Of course, an increase in the capacity is gained by applying the NL equalization, with a percentage improvement close to 13%. The capacities achieved in the multichannel condition are around 62 Gb/s and 54 Gb/s with and without VE, respectively.

The reported measurements have been used to validate a simulative tool, able to model all the different devices/components exploited during the experimental tests. The modeling of the experimental data has been performed to adapt the simulation tool to the system considered in the experimental set-up. The capacities obtained are shown in Figure 3 as dashed curves and empty marks. The experimental and simulative results are in quite good agreement both for single-channel and multichannel transmissions, confirming that the developed simulation tool is able to correctly estimate the performance in presence of NL impairments, such as self-phase modulation (SPM) and XPM, after propagation in hundreds of kilometer links. In the following, some simulative results on multichannel DM-VCSEL-based metro system are reported.



(a) (b)

Figure 4. System performance in terms of capacity achieved after 100-km SSMF propagation without (a) and with (b) NL VE.

Figure 4 shows the performance of the metro system in case of 100-km SSMF propagation in terms of capacity as a function of the optical launch power per channel for different configurations of co-propagating channels with (Figure 4(b)) and without (Figure 4(a)) NL VE. In particular, the single-channel configuration permits to evaluate the impact of SPM; by comparison, the 3-channel condition is used to highlight the impact of XPM depending on the channel spacing, which ranges from 25 GHz to 75 GHz; finally, the 7-channel configuration allows to assess the performance of the system when all C-band channels are switched on, being negligible the effect of a higher number of channels. As a reference, also the single-channel and 3-channel configurations in case of linear propagation are reported: the former represents the single channel BTB performance, while the latter permits to evaluate the crosstalk impact of 25-GHz spaced WDM channels on the capacity. As expected, due to OSNR increase, in linear regime the capacity increases with the launch power; in case of multi-channel propagation (green dotted triangles) the capacity is reduced of a few Gb/s with respect to the single-channel condition (blue dotted circles) owing to the crosstalk of 25-GHz adjacent channels. In NL regime, the capacity shows the typical parabolic trend, with an initial increase (thanks to a better received optical signal-to-noise ratio - OSNR) and a subsequent reduction (owing to the impact of SPM and XPM). The 3-channels configuration has been analyzed for different channel spacings to evidence the different NL behavior. Reducing the channel spacing increases the XPM impact, starting from a very low penalty in case of 75-GHz spacing to a high impact for 25-GHz spaced channels. Moreover, while the curves down to 50-GHz spacing almost match the single-channel one up to the optimal launch power, in case of 25-GHz spacing there is a clear reduction of the supported capacity even for lower optical launch powers. The optimum launch power per channel is in fact around 3 dBm for single channel, 75-GHz and 50-GHz spacings, while for 25-GHz spacing configurations (3-channels and 7-channels) it is close to 0 dBm.

Figure 4(b) analyzes the exploitation of VE; as expected, the performance of the transmission system improves, permitting to support higher capacities, up to 65 Gb/s in BTB. Moreover, the VE is very effective also in the reduction of SPM penalties, as visible from the single-channel NL propagation curve (dotted orange curve). In this case, the supported capacity follows the linear curve without any significant reduction, while without the VE an optimal launch power of 3 dBm and a maximum capacity of 56 Gb/s are obtained. In case of 25-GHz channel spacing there is still a reduction of transmission performance for launch powers higher than 0 dBm: VE thus proves to be less effective in mitigating inter-channel NLs with respect to SPM impairments. However, VE exploitation allows to achieve a capacity of 58 Gb/s even in case of 7 25-GHz-spaced channels up to 100 km of SSMF propagation.

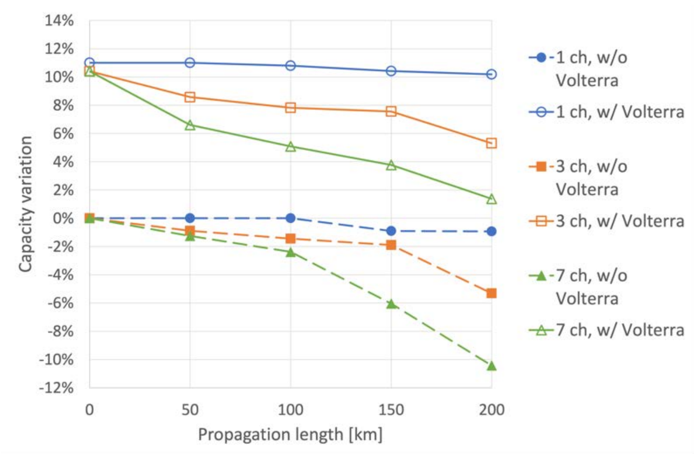


Figure 5.Percentage gains or reductions versus SSMF length with (continuous curves, empty markers) and without (dashed curves, full markers) NL VE for single-channel (blue), 3-channels (orange) and 7-channels (green) transmissions.

Finally, Figure 5 shows the percentage variations with respect to the corresponding reference capacity achievable in case of linear propagation without equalization. The analysis is performed at the optimal launch power for each distance with (continuous line) and without VE (dashed line). The presented values, therefore, represent the net maximum gains (in case of active VE) or the net minimum reduction (in case of absence of equalization), since the respective reference capacities are obtained at the corresponding OSNR values.

By analyzing the single-channel results, it appears that the impact of intra-channel NLs (e.g., SPM) is negligible in the optimal working condition for the considered fiber lengths. Even without equalization, the capacity achievable after 200 km shows a decrease of about the 1% of the corresponding reference linear regime. This means that the main impairment limiting the single-channel transmission is the OSNR variation with fiber length. Primarily, the VE is pretty effective in overcoming intra-channel NL impairments, reaching gains close to 11% for all the distances. On the other hand, the presence of adjacent channels leads to a general worsening of the system performance, also for the 25-GHz spaced 3-channel system. Considering the multi-channel propagation without equalization, the impact of adjacent channels is evident after 100-km lengths, reaching a reduction of about -11% at 200 km with 7 co-propagating channels caused mostly by inter-channel NLs. In presence of VE, instead, a gain can still be achieved in multi-channel configurations. It is interesting to notice that there is a VE gain reduction with SSMF propagation length and channels number, showing that inter-channel NL accumulation progressively decreases the VE efficiency. Anyway, VE exploitation still permits to obtain a net gain of 2% even after 200-km SSMF propagation with 7 active channels.

In conclusion, the performed experimental and simulative analysis at POLIMI premises confirms that the VCSEL-based TX assures at least 50-Gb/s transmission, according to the expected results, over more than 100-km uncompensated SSMF links in presence of coherent detection. Longer distances can be reached also in case of NL impairments due to the presence of adjacent channels with 25-GHz granularity, exploiting the effectiveness of the NL VE. However, 25-GHz dense granularity is used just at the higher hierarchical levels, such as in case of HL3-HL2/1 paths, when the employment of the fully equipped PASSION TX is required.

2.3 TX MODULE INTEGRATION

SMO invested an important effort to integrate the PASSION 40-VCSEL TX module, realized by VTT and targeting up to 2-Tb/s capacity, in a real industrial platform based on LM1-WDM/LM1-OTN products. VTT 2-Tb/s TX module integration is surely a very challenging activity aimed at integrating PASSION technology in an industrial environment. Starting from the PIC specifications, SMO developed an evaluation board, following the standard industrial process used for products.

2.3.1 Preliminary activity

Taking in account the transmitter requirements, SMO performed a preliminary activity to identify the implementation targets of the evaluation board:

1. use an ETSI standard mechanic (LM-1 family subrack – Figure 6);
2. support rates up to 56Gb/s PAM4 on a single channel
3. fully reuse the common parts for power supply, cooling and control;
4. integrate a powerful CPU platform to be ready for providing additional functionalities such as enhanced debug and measurements, control, monitoring.

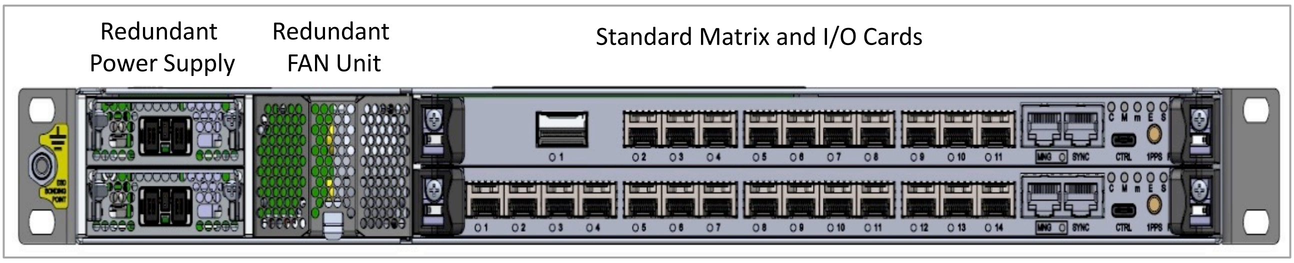


Figure 6. Standard LM1 family product.

SMO and VTT set dedicated-meetings to analyse all technical details needed to carry out a consistent design of the evaluation board. Due to the transmitter requirements/ constraints some compromises were made in the final design: (i) it is possible to accommodate only one board in a subrack with two slots, due to the need to mount the thermoelectric cooler (TEC) and a heatsink on the opposite surfaces of the chip (Figure 7); (ii) only 10 out of 40 high speed connector are available at the front panel, however the remaining 30 connector are available on the board to allows full testing of the 40 channels.

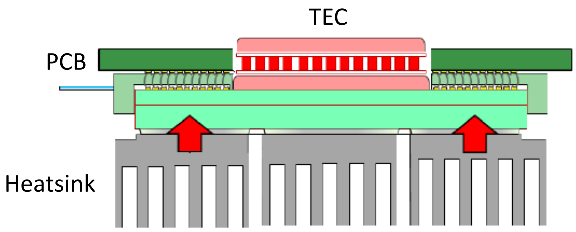


Figure 7. TEC + heatsink require considerable vertical space.

Moreover, normalisation activity to include the VTT component in the Company database (providing information related to drawing symbol, pin list, mechanical specs, etc.) was necessary to include the board design and manufacturing in the standard SMO industrial process.

2.3.2 Evaluation Board Architecture

The evaluation board is based on the standard LM1 board layout. Figure 8 shows the main architectural building blocks.

All the *common parts*, namely power supply, fan units, voltage conversion a power distribution, has been taken from the LM1 products. In particular, the power supply architecture (Figure 9) target the following performances:

- 48V Battery and 3.6V Service Power Redundancy
- Fully Digital Power Converter with PMBus for Control and Monitoring
- Power Architecture based on intermediate low voltage Power Bus (12V)
- Estimated Board Power Consumption ~65W

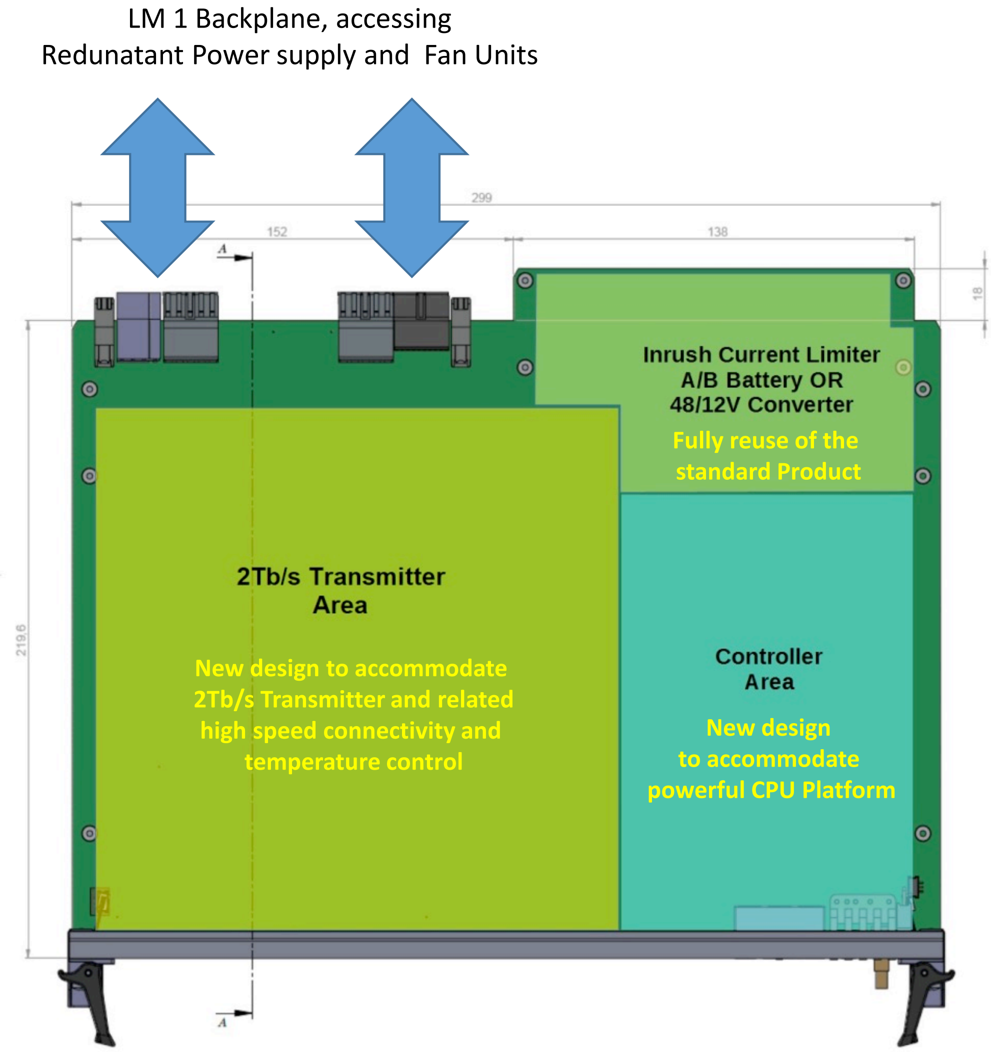


Figure 8. High level board architecture.

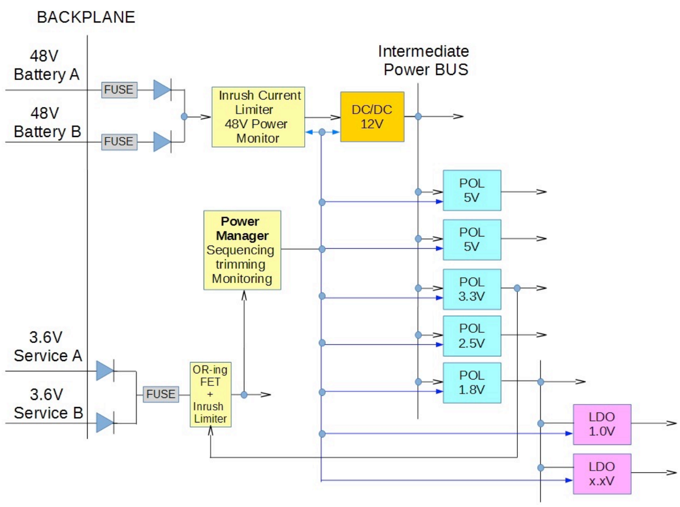


Figure 9. Power architecture.

For the *control platform*, we introduce a modular approach, providing a “COM Express Type 7” interface, being able to accommodate a scalable CPU platform, ranging from low power microcontroller to high end CPU. We decide to use an Intel C3000 based module (Figure 10).

COMPLIANCE	COM Express® Basic, Pin-out Type 7
DIMENSIONS (H x W x D)	95 x 125 mm
CPU (SoC)	Commercial temperature: Intel® Atom® Processor C3958, 16C, 2.0GHz, 31W TDP Intel® Atom® Processor C3858, 12C, 2.0GHz, 25W TDP Intel® Atom® Processor C3758, 8C, 2.2GHz, 25W TDP Intel® Atom® Processor C3558, 4C, 2.2GHz, 16W TDP Industrial temperature: Intel® Atom® Processor C3808, 12C, 2.0 GHz, 25 W TDP Intel® Atom® Processor C3708, 8C, 1.7 GHz, 17 W TDP Intel® Atom® Processor C3508, 4C, 1.5 GHz, 11 W TDP Intel® Atom® Processor C3308, 2C, 1.6 GHz, 9 W TDP
MAIN MEMORY	2x DDR4 SODIMM for up to 32 GByte ECC / non ECC on request: 4x DDR4 SODIMM for up to 64 GByte ECC / non ECC
ETHERNET CONTROLLER	Intel® I210IT (uses one lane of PCIe 3.0) Intel® Quad 10GbE LAN integrated in SoC
ETHERNET	1x 10/100/1000 MBit Ethernet Up to 4x 10GbE Interfaces (KR) – depending on C3000 SKU NC-SI support
HARD DISK	Up to 2x SATA3, 6Gb/s
FLASH ONBOARD	eMMC 5.0 up to 64 GByte SLC or 128GByte MLP (build option)
PCI Express®/ PCI SUPPORT	Up to 14x PCIe 3.0 lanes - depending on C3000 SKU
USB	Up to 3x USB 3.0 / USB 2.0
SERIAL	2x serial interface (RX/TX only)
COMMON FEATURES	SPI, LPC, SMB, Fast I²C, Staged Watchdog, RTC
ON REQUEST	eMMC size, additional 2 SODIMM sockets for overall 4 SODIMM sockets

Figure 10. Kontron COMe-bDV7 CPU Platform.

Figure 11 shows the general control architecture, where I2C has been highlighted, being the fundamental communication infrastructure used for low level configuration.

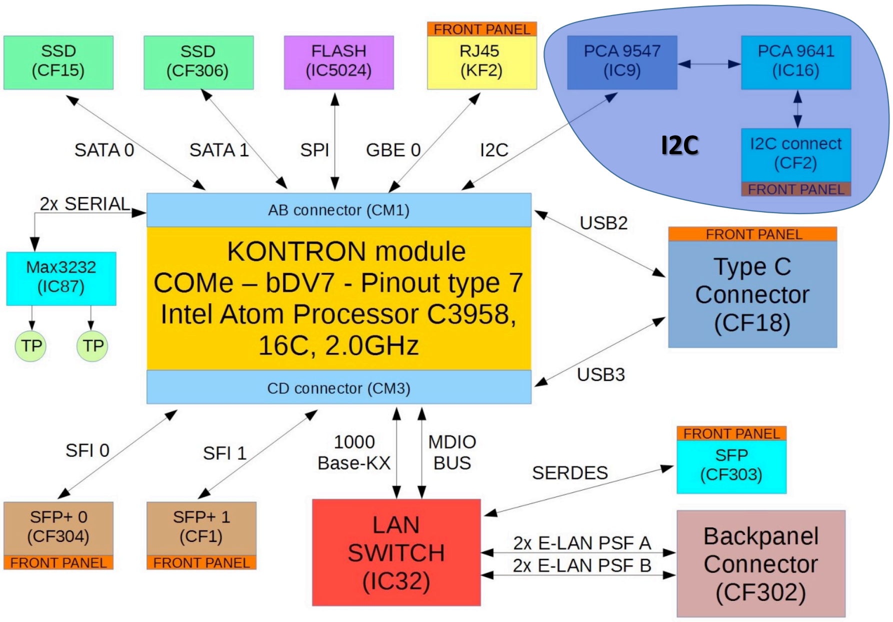


Figure 11. General control architecture.

In order to mitigate possible risks, the I2C infrastructure can be alternatively controlled by local CPU, by remote CPU based on actual LM1 control platform and from an external PC with a suitable I2C controller installed on it.

Most of the remaining space of the evaluation board is allocated for the integration of the 2Tb/s transmitter chip.

2.3.3 Board Design

During the design we have to face some challenging requirements, mainly due to the transmitter device: (i) "unconventional" form factor; (ii) double side device, (iii) mechanical mounting by using compression clamps; (iv) fibre pigtail on the bottom of the printed circuit board (PCB); (v) very dense analog lines.

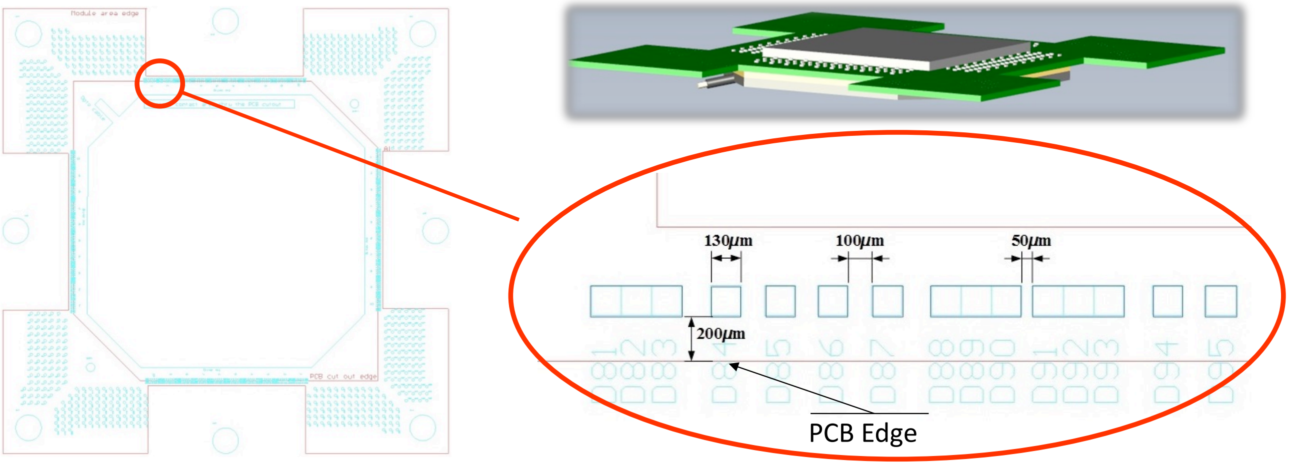


Figure 12. Very low pitch of analog pins.

Following the internal standard process, SMO developed the mechanical and electrical design of the evaluation board. It is worth to highlight some of the critical aspects, which have been addressed during the development.

High speed (RF) layout and interconnections - Routing and hosting 40 dual connectors (p/n) on the front panel of the card for full access to the Module was critical. In order to prioritise the performance we decided to spread the majority of the analog input connector on the board top side, making available ten inputs on the front panel. This choice does not prevent the full testing capability of the transmitter chip (30 dual connectors can be accessed for test purposes using a shelf without the top closure panel), while relaxing the RF lines routing issue. The selected connectors (Figure 12) are suitable for HS mounting on TOP layer without vias and can be easily coupled with a transmitter module that can be routed on TOP layer as well.

Figure 13. Selected Connectors are SMPM (GPPO compatible), up to 65GHz.

Routing on TOP layer without vias improves return loss but the geometry of the trace is not fully under control due to plating and finishing process, and also copper roughness is not optimal. Signal integrity simulations were carried out to evaluate an alternative routing on Layer 2 as "embedded microstrip" using laser vias (No stub) to contact the Layer and to evaluate the penalty (IL/RL) of

HITACHI PCB material compared to MEGRON6 in case it was required an alternative solution. Finally, layout on TOP layer has been selected since it has much better return losses due to missing vias. The difference between MEGTRON6 and HITACHI is negligible. Hitachi is slightly better due to further improvement on return losses despite very small degrade on insertion losses.

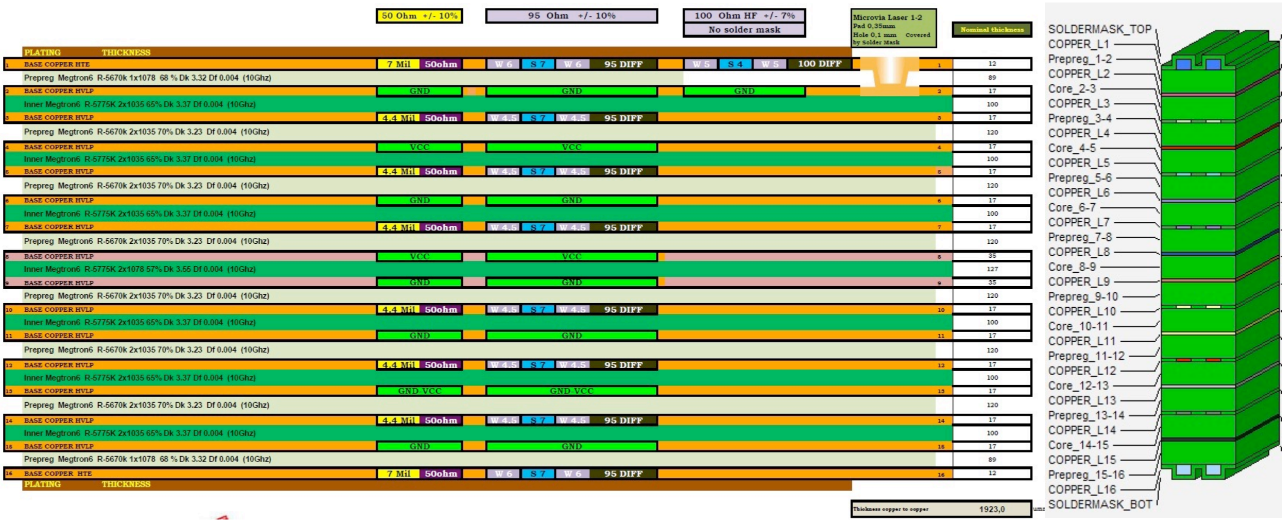


Figure 14. Initial study using MEGRON6.

Based on consolidated experience, SMO developed the *I2C control bus* in such a way to leave open alternative control paths, with the purpose of having alternative solutions in case of issues:

- I2C is the main control bus of the card (Figure 15)
- I2C also controls the FANs Tray and Power Cards
- 40 I2C Bus connected to the "Transmitter Module" to control VCSEL drivers (with same I2C address) are achieved by Mux cascading architecture
- I2C debug port available to be connected to external processor.

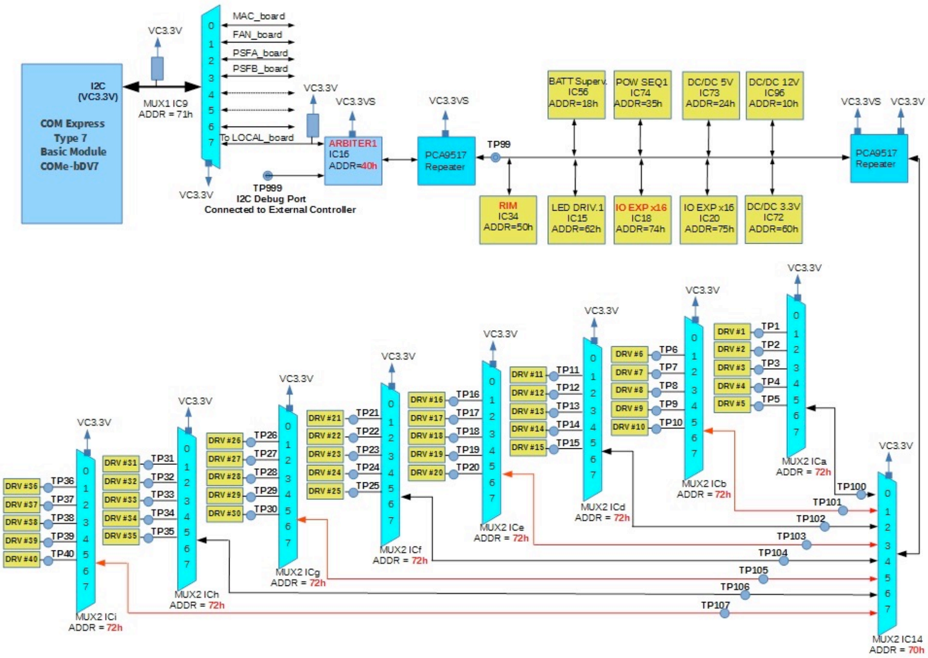


Figure 15. I2C control architecture.

The results of the designing process are summarized in the appendix.

After the design phase SMO transferred the *PCB* manufacturing and assembly to an external Company. Among his standard suppliers SMO selected the one with the technological capability suitable to address the challenging design target. However, for this special item, the R&D Lab. personnel was constantly involved in all the manufacturing steps, to provide the needed support and ultimately to guarantee the quality of the result. It is worth to highlight the encountered main critical aspects:

Board Planarity & Board Finishing

- Critical to guarantee electrical contact on Compression Mounting Device
- Small Pads close to the PCB edge makes these points worse
- Finishing could impact on selected PCB materials – trade-off with performance may be required
- PCB thickness is a critical parameter to accommodate robustness, planarity and fibre pigtail routing

Accuracy on centring hole position, pad size and alignment

- Very small PAD size for HS signals requires extreme accuracy on PCB.

Finally, Hitchi material with 2mm of thickness was chosen. Quality report on the manufactured PCB is attached in the Appendix.

After the manufacturing process, the external manufacturer delivered four samples of the evaluation board to SMO hardware lab for the final assembly of auxiliary parts, including VTT TX module, mounted using the mechanical clamps provided by VTT (Figure 16). Some initial debug activity was necessary to perform a "sanity check" of the four prototypes. Visual inspection showed some minor issues related to few missing components, wrong mounting of some components and few welding issues. The lab was able to fix them directly. Further verification of power supply, control busses, CPU platform was positive, confirming that the overall environment was ready to integrate the transmitter component.

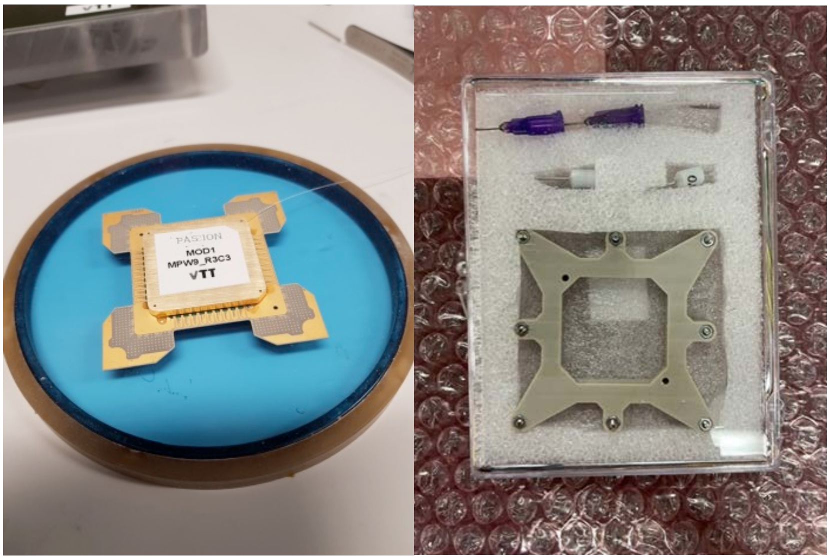


Figure 16. VTT 2-Tb/s TX module and related mechanical clamps.

Figures 17, 18 and 19 show the final board and the 1RU TX node.

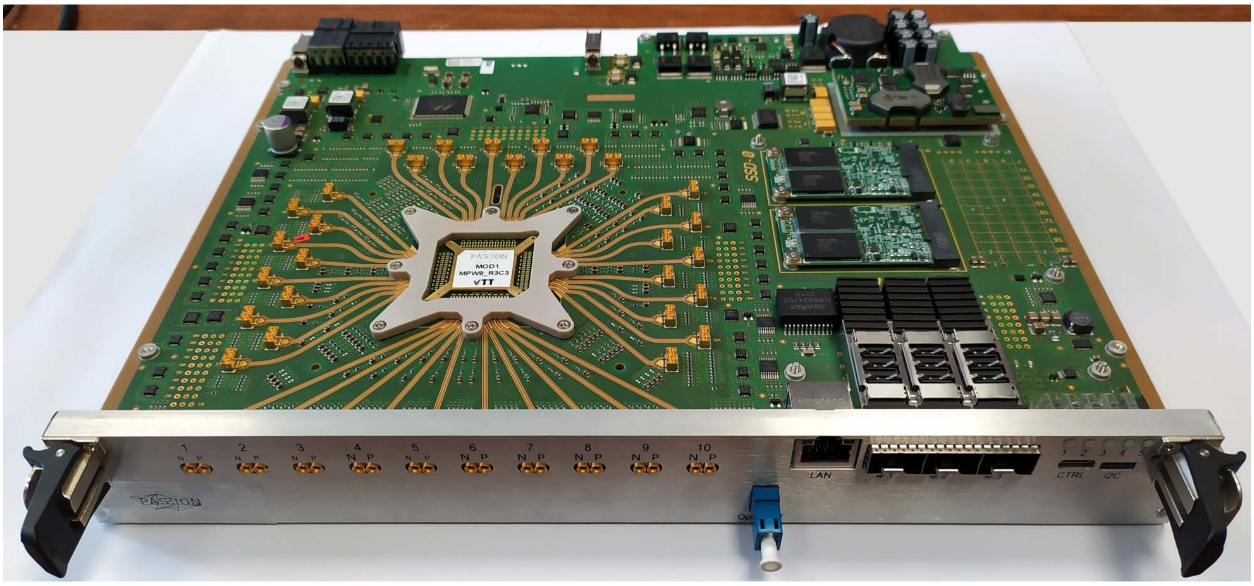


Figure 17. Top view of the final 2-Tb/s transmitter board without heat sink

Figure 18. Top view of the final 2-Tbs transmitter board

Figure 19. Final 2-Tb/s transmitter board integrated in the ETSI 300mm Subrack.

2.3.4 Board debug

Some initial debug activity was necessary to perform a “sanity check” of the four prototypes. Visual inspection showed some minor issues related to few missing components, wrong mounting of some components and few welding issues. The lab was able to fix them directly. Further verification of power supply, control busses, CPU platform was positive, confirming that the overall environment was ready to integrate the transmitter component. Internal outcomes of the transmitter chip prevent the direct completion of the debug phase.

2.3.5 Software development

SMO developed a software application to control the evaluation board, providing the external interfaces needed to integrate the “transmitter” node into the final PASSION Demo. According to the architecture of Figure 20, the developments includes low level drivers, Transmitter Yang Model, Agent module suitable to be interfaced with CTTC SDN Controller. In order to mitigate possible development risks we made available three alternative methods to control the Transmitter chip:

A) Based on external PC using an I2C/USB board
B) Based on External LM1 nodes, reusing the full product stack with the integration of the Transmitter specific Yang Model
C) Based on the Local CPU platform with dedicated application development.

Considering the project evolution, we focused our effort on method B). This choice demonstrated a real integration of the transmitter module in the LM1 industrial tool chain, starting from the Yang model definition, fully reusing the complete board driver infrastructure and the Agent. The resulting solution is less integrated, but it gives an idea of a real integration PASSION technology in an industrial product.

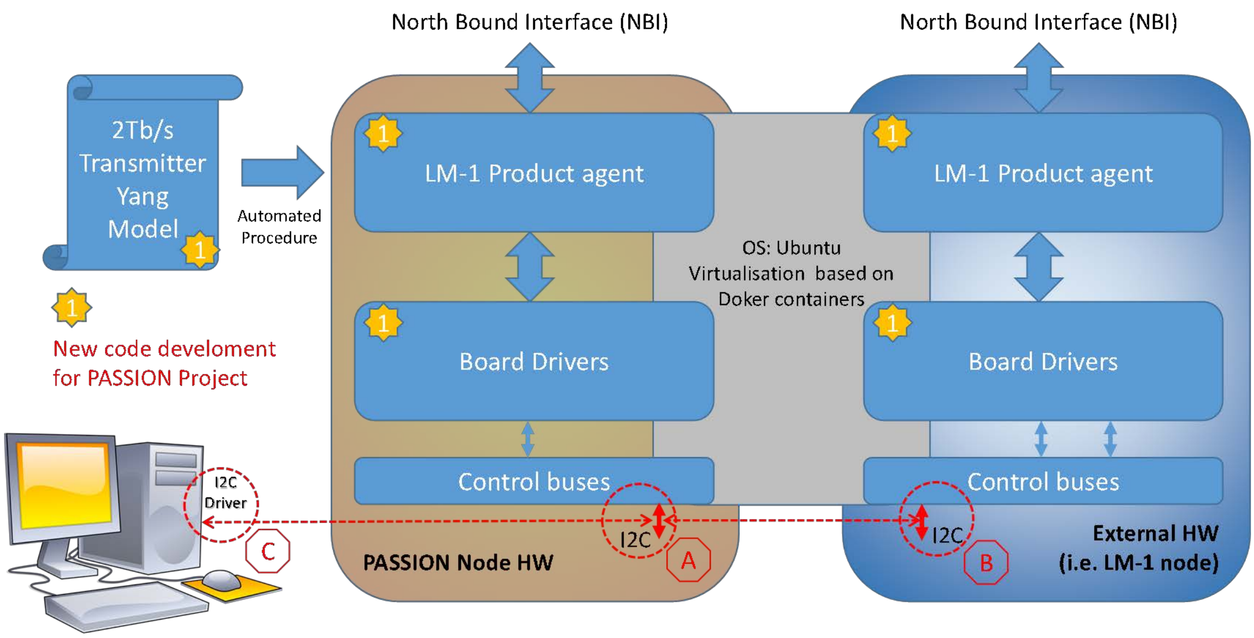


Figure 20. Transmitter application SW architecture

2.3.5.1 Yang Model

tail-f

Module: sbvt-transmitter, Namespace: urn:passion-project:eu:yang:sbvt-tx, Prefix: sbvt-tx
Module: sbvt-receiver, Namespace: urn:passion-project:eu:yang:sbvt-rx, Prefix: sbvt-rx
Module: sbvt-switch, Namespace: urn:passion-project:eu:yang:sbvt-switch, Prefix: sbvt-xc

Element [+]Expand all [-]Collapse all	Schema	Type	Flags	Opts	Status	Path
sbvt-transmitter	module					
sbvtTx	container		config		current	/sbvt-tx:sbvtTx
numModulesTx	leaf	uint8	no config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:numModulesTx
modulesTx[moduleTxId]	list		no config		current	/sbvt-tx:sbvtTx/sbvt-tx:modulesTx
moduleTxId	leaf	uint16	no config		current	/sbvt-tx:sbvtTx/sbvt-tx:modulesTx/sbvt-tx:moduleTxId
subModulesTx[subModuleTxId]	list		no config		current	/sbvt-tx:sbvtTx/sbvt-tx:modulesTx/sbvt-tx:subModulesTx
subModuleTxId	leaf	uint16	no config		current	/sbvt-tx:sbvtTx/sbvt-tx:modulesTx/sbvt-tx:subModulesTx/sbvt-tx:subModuleTxId
VCSELs[vcselId]	list		no config		current	/sbvt-tx:sbvtTx/sbvt-tx:modulesTx/sbvt-tx:subModulesTx/sbvt-tx:VCSELs
vcselId	leaf	uint16	no config		current	/sbvt-tx:sbvtTx/sbvt-tx:modulesTx/sbvt-tx:subModulesTx/sbvt-tx:VCSELs/sbvt-tx:vcselId
central-frequency	leaf	decimal64	no config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:modulesTx/sbvt-tx:subModulesTx/sbvt-tx:VCSELs/sbvt-tx:central-frequency
used-state	leaf	boolean	no config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:modulesTx/sbvt-tx:subModulesTx/sbvt-tx:VCSELs/sbvt-tx:used-state
bandwidth	leaf	uint16	no config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:modulesTx/sbvt-tx:subModulesTx/sbvt-tx:VCSELs/sbvt-tx:bandwidth
modulation-format	leaf	sbvt:modulation-type	no config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:modulesTx/sbvt-tx:subModulesTx/sbvt-tx:VCSELs/sbvt-tx:modulation-format
fec	leaf	sbvt:fec-type	no config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:modulesTx/sbvt-tx:subModulesTx/sbvt-tx:VCSELs/sbvt-tx:fec
connections[connectionId]	list		config		current	/sbvt-tx:sbvtTx/sbvt-tx:connections
connectionId	leaf	string	config		current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:connectionId
(vcselRef)	choice		config	Choice	current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef
:(BY-FREQ-SLOT)	case		config		current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef
sbvtTxFreqSlot[centerFreq_n]	list		config		current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtTxFreqSlot
centerFreq_n	leaf	int16	config		current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtTxFreqSlot/sbvt-tx:centerFreq_n
slotWidth_m	leaf	uint8	config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtTxFreqSlot/sbvt-tx:slotWidth_m
used-state	leaf	boolean	config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtTxFreqSlot/sbvt-tx:used-state
bandwidth	leaf	uint16	config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtTxFreqSlot/sbvt-tx:bandwidth
modulation-format	leaf	sbvt:modulation-type	config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtTxFreqSlot/sbvt-tx:modulation-format
fec	leaf	sbvt:fec-type	config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtTxFreqSlot/sbvt-tx:fec
:(BY-COORDS)	case		config		current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef
sbvtCoords[moduleId subModuleId vcselId]	list		config		current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtCoords
moduleId	leaf	uint16	config		current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtCoords/sbvt-tx:moduleId
subModuleId	leaf	uint16	config		current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtCoords/sbvt-tx:subModuleId
vcselId	leaf	uint16	config		current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtCoords/sbvt-tx:vcselId
used-state	leaf	boolean	config	?	current	/sbvt-tx:sbvtTx/sbvt-tx:connections/sbvt-tx:vcselRef/sbvt-tx:sbvtCoords/sbvt-tx:used-state
sbvt-receiver	module					
sbvtRx	container		config		current	/sbvt-rx:sbvtRx
numModulesRx	leaf	uint8	no config	?	current	/sbvt-rx:sbvtRx/sbvt-rx:numModulesRx
modulesRx[moduleRxId]	list		no config		current	/sbvt-rx:sbvtRx/sbvt-rx:modulesRx
moduleRxId	leaf	uint16	no config		current	/sbvt-rx:sbvtRx/sbvt-rx:modulesRx/sbvt-rx:moduleRxId
numOpticalReceivers	leaf	uint8	no config	?	current	/sbvt-rx:sbvtRx/sbvt-rx:modulesRx/sbvt-rx:numOpticalReceivers
opticalReceivers[opticalReceiverId]	list		no config		current	/sbvt-rx:sbvtRx/sbvt-rx:modulesRx/sbvt-rx:opticalReceivers
opticalReceiverId	leaf	uint16	no config		current	/sbvt-rx:sbvtRx/sbvt-rx:modulesRx/sbvt-rx:opticalReceivers/sbvt-rx:opticalReceiverId
used-state	leaf	boolean	no config	?	current	/sbvt-rx:sbvtRx/sbvt-rx:modulesRx/sbvt-rx:opticalReceivers/sbvt-rx:used-state
bandwidth	leaf	uint16	no config	?	current	/sbvt-rx:sbvtRx/sbvt-rx:modulesRx/sbvt-rx:opticalReceivers/sbvt-rx:bandwidth
freqLocalOscillator	leaf	decimal64	no config	?	current	/sbvt-rx:sbvtRx/sbvt-rx:modulesRx/sbvt-rx:opticalReceivers/sbvt-rx:freqLocalOscillator
connections[connectionId]	list		config		current	/sbvt-rx:sbvtRx/sbvt-rx:connections
connectionId	leaf	string	config		current	/sbvt-rx:sbvtRx/sbvt-rx:connections/sbvt-rx:connectionId
sbvtRxFreqSlot[freqLocalOscillator_n]	list		config		current	/sbvt-rx:sbvtRx/sbvt-rx:connections/sbvt-rx:sbvtRxFreqSlot
freqLocalOscillator_n	leaf	int16	config		current	/sbvt-rx:sbvtRx/sbvt-rx:connections/sbvt-rx:sbvtRxFreqSlot/sbvt-rx:freqLocalOscillator_n
used-state	leaf	boolean	config	?	current	/sbvt-rx:sbvtRx/sbvt-rx:connections/sbvt-rx:sbvtRxFreqSlot/sbvt-rx:used-state
sbvt-switch	module					
sbvtSwitch	container		config		current	/sbvt-xc:sbvtSwitch
ports[portId]	list		config		current	/sbvt-xc:sbvtSwitch/sbvt-xc:ports
portId	leaf	uint16	config		current	/sbvt-xc:sbvtSwitch/sbvt-xc:ports/sbvt-xc:portId
portType	leaf	enumeration	config	?	current	/sbvt-xc:sbvtSwitch/sbvt-xc:ports/sbvt-xc:portType
used-state	leaf	boolean	config	?	current	/sbvt-xc:sbvtSwitch/sbvt-xc:ports/sbvt-xc:used-state
connections[connectionId]	list		config		current	/sbvt-xc:sbvtSwitch/sbvt-xc:connections
connectionId	leaf	string	config		current	/sbvt-xc:sbvtSwitch/sbvt-xc:connections/sbvt-xc:connectionId
portIn	leaf	leafref	config	?	current	/sbvt-xc:sbvtSwitch/sbvt-xc:connections/sbvt-xc:portIn
portOut	leaf	leafref	config	?	current	/sbvt-xc:sbvtSwitch/sbvt-xc:connections/sbvt-xc:portOut
centerFreq_n	leaf	int16	config	?	current	/sbvt-xc:sbvtSwitch/sbvt-xc:connections/sbvt-xc:centerFreq_n
slotWidth_m	leaf	uint8	config	?	current	/sbvt-xc:sbvtSwitch/sbvt-xc:connections/sbvt-xc:slotWidth_m

Figure 21. PASSION components Yang Model

In line with the architectural activity done in WP2, and with the SDN controller implementation (see D5.2), SMO developed Yang Models (Figure 21) of all PASSION devices (transmitter, receiver and switch). In line with the Project objectives, only the transmitter part has been used for Agent implementation.

2.3.5.2 OS and Board Drivers

Kontron CPU Module ***(A)****:*
Installation via usbkey ubuntu xenial/bionic via iso image/serial interfaces
Building kernel ubuntu hwe 4.15 installation
Driver and API porting on x86:

1. pca9641 i2c arbiter
2. sc18is602b bridge i2c/spi
3. ltc2662 spi DAC
4. pca9553 i2c LED driver
5. pca9539 i2c GPIO

6. pca6408 i2c GPIO
7. bmr461 PMBUS DC/DC
8. adm1075 PMBUS Battery supervisor
9. adm1166 i2c-dev Power-sequencer
10. pca9547 i2c-mux
11. rim at24cm01

*Common development for LM1/Kontron **(A/B)**:*

- API via sysfs, for LM1 arm64 labeling sysfs driver via device-tree
- API via sysfs/dev for x86 without fwts but with init script
- Command to init/setting device for bringup and configuration of board

*Application for LM1 arm64 **(A):***
configuration/monitoring sensor temperature/power sequencer/power management devices

*Work not completed **(A)**, not included in the final integration*

- FWTS table to create the table and load dynamic table at runtime to be compatible with LM1 API on x86
- Customization of the application designed and ready to be tested based on arm64 cpu in order to match device-tree labelling on FWTS In order to full use Kontron cpu with LM1 API

2.3.5.3 Agent

Thanks to the industrial toolchain available for product development, the agent code was generated without the need of dedicated development/customisation. Integration activity with CTTC SDN Controller is reported in D5.4.

3 PASSION SWITCHING ASSESSMENT AND INTEGRATION

3.1 SWITCHING/AGGREGATION NODE ARCHITECTURE

The switching/aggregation node architecture is designed in order to support the network organized in hierarchical levels. Figure 22 presents the photonic space switch exploited to drop the incoming traffic or to assign it to the express out path. Aggregate/disaggregate switches allow the routing of the dropped traffic either to the multicast switch (MCS) or to the add switch WSS. The switch is based on the operation of semiconductor optical amplifiers (SOAs). For the uplink traffic, a WSS-based add switch is employed to enable contention-less, directionless and colourless add of the traffic to the other nodes. Switching and routing in space and in spectrum are enabled by this kind of architecture. The presented node architectures is implemented with a modular approach adopted by repeating the same functional blocks.

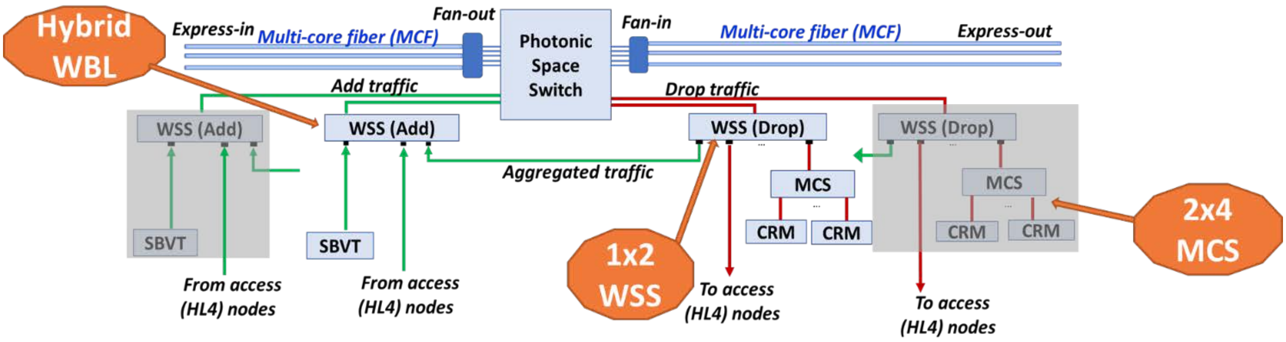


Figure 22. PASSION switching node architecture (the tested switching functions are highlighted in orange).

3.2 SWITCHING NODE INTEGRATED TECHNOLOGY ASSESSMENT

As illustrated in Figure 22, the PASSION node architecture is based on two types of integrated switches, i.e. the WSS and the MCS. As a result, for the assessment of the switching node the operation of the hybrid wavelength blocker (WBL), of the monolithic InP 1x2 WSS and of the 2x4 MCS have been experimentally evaluated at TUE lab. The assessment is based on the performance metrics such as insertion loss, extinction ratio, and output OSNR. The setup for assessing the performance of on-chip switches is given in Figure 23 and the mask layout of the three measured switches in Figure 24.

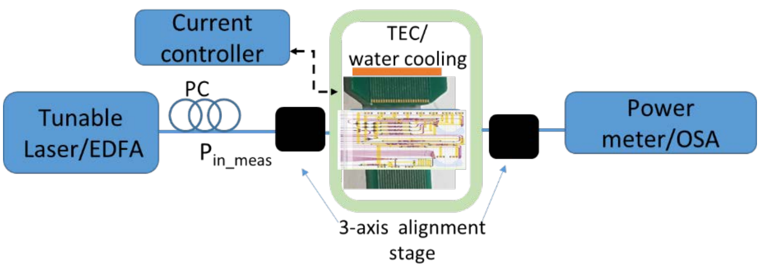


Figure 23. Fiber-to-chip coupling setup, tunable source/ EDFA noise source / power meter and optical spectrum analyzer.

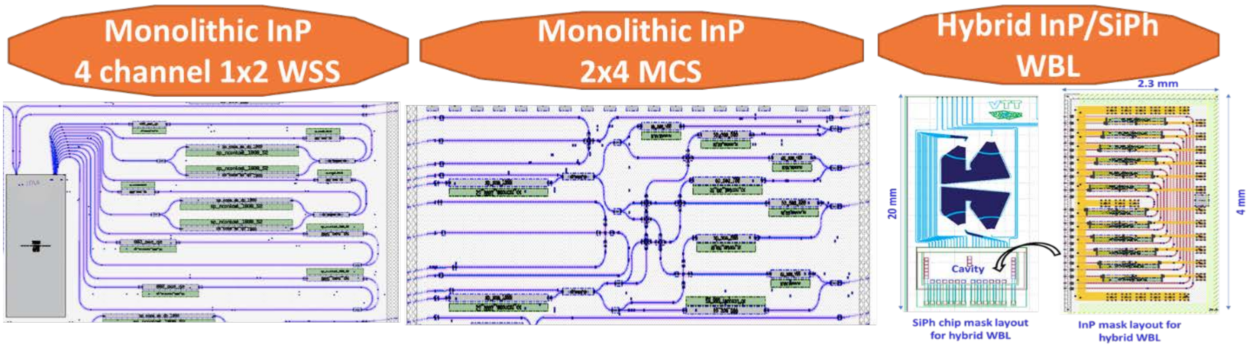


Figure 24. Mask layout of the assessed on-chip switches.

3.2.1 Hybrid WBL

The hybrid WBL is electrically and optically characterized. Out of the 10 wavelength channels, 8 channels Ch1, Ch3, …, Ch9 are working and were characterized optically and electrically. Figure 25 shows the I-V curve of the SOA gate switches before and after flip chip bonding (FCB) assembly. Comparing the I-V curve before and after integration, only a variation of 4.5 Ohms in resistance is observed.

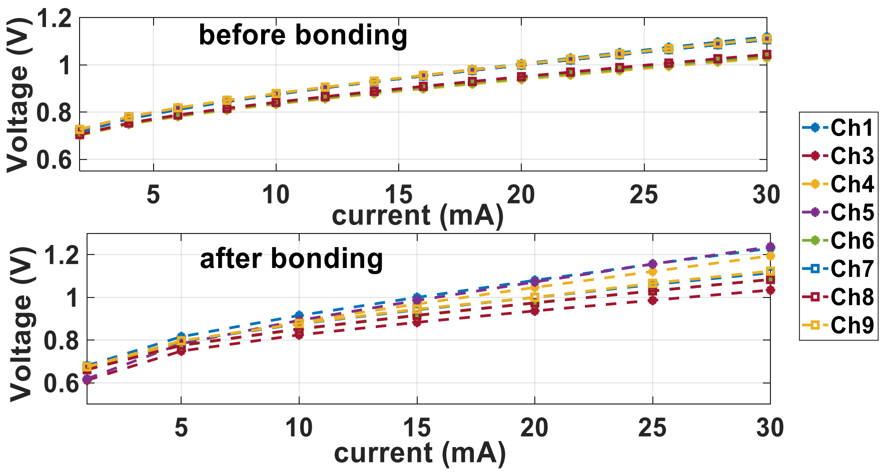


Figure 25. I-V curve of the SOAs before and after flip-chip bonding.

Figure 26(a) shows the transmission characteristics of eight wavelength channels when the SOA gates are On/Off for an input optical power of 0 dBm. Solid lines represent the WBL output when the gate SOA is On state and dashed line shows the WBL output when the gate SOA is in the Off state. Typical measured On/Off ratio is around 30 dB. The fiber-to-fiber losses for Ch1, Ch3, Ch6, Ch7, Ch8 range from 32.2 to 37.5 dB. The current for each gate SOA is optimally tuned to minimize both the fiber-to-fiber loss and the effect of back reflections on the hybrid WBL. Accounting for 2.5 dB insertion loss per AWG and 3 dB/facet for chip-to-fibre coupling losses and 3-dB gain of the SOA at 40 mA, the best channel (Ch3) has 12 dB/facet hybrid coupling loss: resulting in an excess loss of 9dB/facet. We believe the measured excess losses are the result of tight alignment tolerance which can be improved by reducing the air-gap (now in the order of 8μm); additionally, it can be relaxed by using on-chip integrated spot-size converters. Also, the use of angled waveguides can alleviate the back reflection impact and fully employ the gain of SOAs. Figure 26(b) shows the gain characteristics of the gate SOA for Ch3 for varying current and varying input power. It is shown that the fibre-to-fibre loss varies from 60 dB at the absorption state of the SOA at 0 mA to 26 dB due to gain provided by the SOA at 100mA. The fibre-to-fibre loss is in the order of 33 dB at 80 mA for all input power values. The loss decreases to 26 dB at the SOA current of 100mA; for input power of 0 dBm and -5 dBm. Effects of the SOA saturation on the fibre- to-fibre loss is slightly observed at 100 mA for input powers of 7 dBm and 10 dBm, resulting in fibre-to-fibre losses of 29 dB and 31.57 dB respectively.

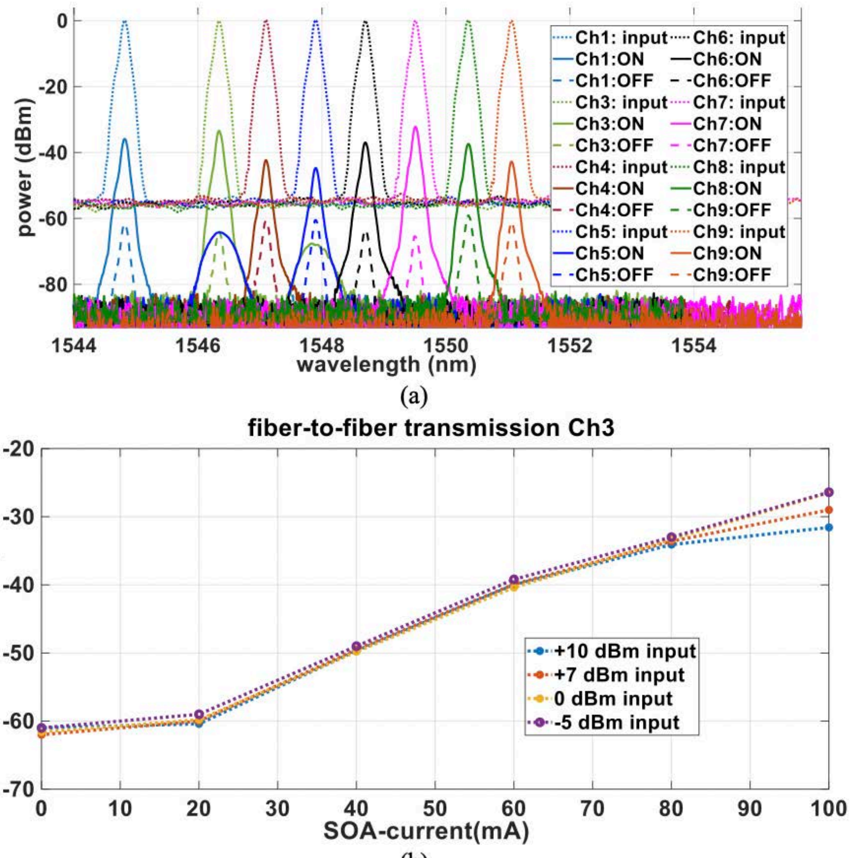


Figure 26. (a) Input optical signal (dotted line), output optical signal of the Hybrid WBL switch ON (solid line) /Off state (dashed line). (b) Fiber-to-fiber transmission and gain characteristics of SOA (Ch3).

3.2.2 Monolithically InP 1x2 WSS

A compact 1x2 WSS was designed and experimentally characterized. The design is based on a single 3x12 AWG which enables switching of 4 channels. The performance results show promising prospect on monolithic InP WSS. Figure 27(a) shows the transmission characteristics of 3x12 AWG.

The transmission spectrum was obtained by using the ASE of the EDFA wideband input and the spectrum in Figure 27(a) is normalized with respect to the input. It can be clearly seen that the right combination represented by the same color plot spectrally overlap, as desired. Furthermore, the channel spacing is the same as the design value of 400 GHz. The insertion loss of each channel measured by tuning the laser at the central wavelength ranges between 3 dB and 5.8 dB. The signal to crosstalk level is more than 30 dB. The spectral matching between the port combination shows 1x2 switching capability.

Next, the laser light corresponding to the 4 channels (Ch1 at 1549.78 nm, Ch2 at 1553 nm, Ch3 at 1556.2 nm and Ch4 at 1559.4 nm) is coupled to the 1x2 WSS and the measured power is given in

Figure 27(b). The insertion loss ranges between 7 dB for Ch2 to 12 dB for Ch4. This is line with 2 x 5 dB insertion loss of the AWG (signal crosses two times the AWG), and 3 dB multimode interference (MMI) splitting loss as well as 5 dB gain by the gate SOAs. For Ch3 and Ch4 an extra loss of 5 dB is incurred due to Mach-Zehnder Interferometer (MZI) switching. These losses can easily be compensated by a booster SOA at the input of the WSS. On the other hand, an extinction ratio as high as 33 dBs is achieved.

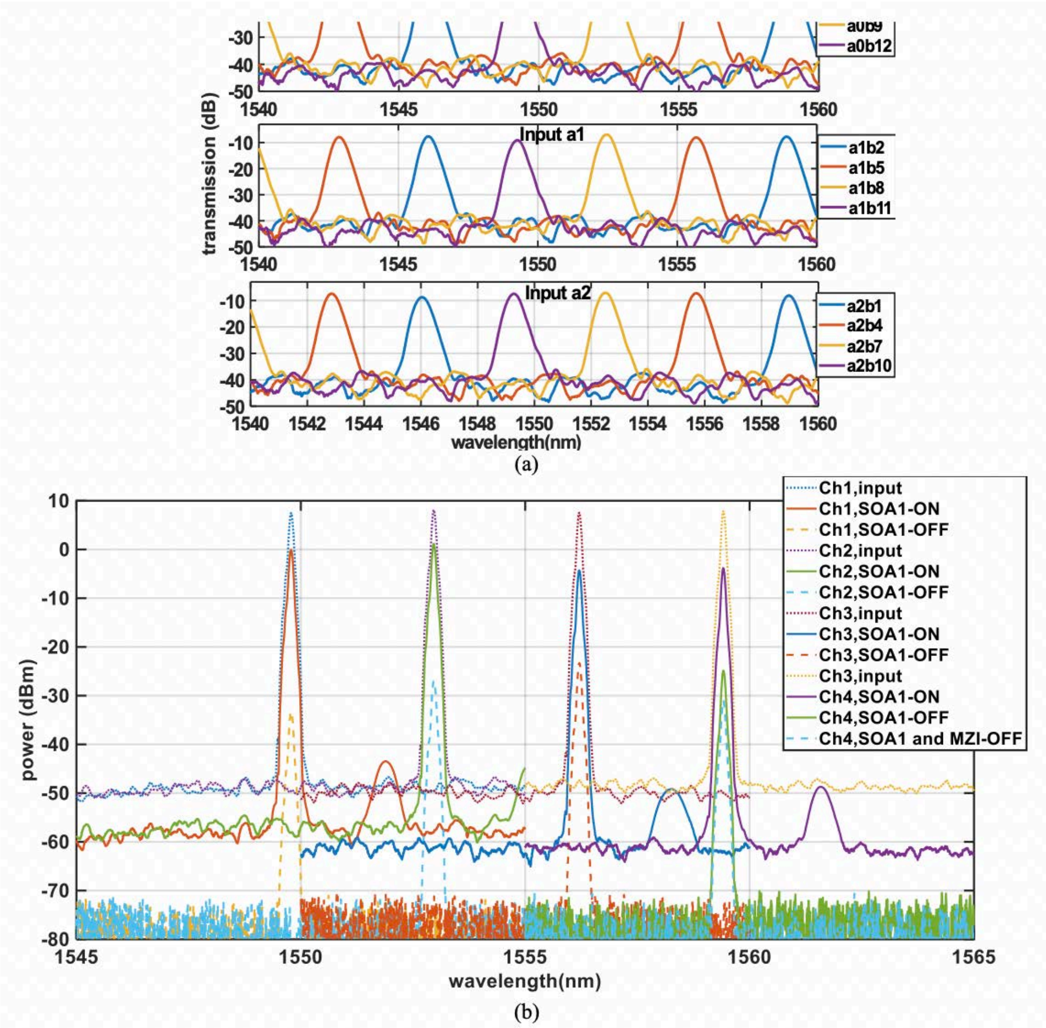


Figure 27. (a) measured transmission characteristic of 3x12 AWG. (b) Measured output power of 1x2 WSS, 4 wavelength channels.

3.2.3 Monolithically InP 2x4 MCS

The 2x4 MCS is experimentally characterized by testing the input/output connectivity by turning on one booster SOA and one gate SOA at a time. At first the path I1 => O4 (input 1 to output 4) was tested, by injecting 50 mA of current on the gate SOA and by sweeping the booster SOA from 0 mA to 150 mA. The input power is fixed at -10dBm. The output power measured at different booster current is given in Figure 28(a). The MCS enables fibre-to-fibre gain of +5 dB when booster current is tuned at 150 mA. These corresponds to a total gain of 26 dB, due to the on-chip loss of 9 dB by the 2x4 MMI splitter and 2x1 MMI combiners and 2x6 dB of fibre-to-chip coupling losses. It can be noticed that the booster starts to show signs of saturation after 100 mA. Next the booster current is fixed at 80mA and the gate current is varied between 0 and 80 mA the collected power is shown in Figure 28(b). Fibre-to-fibre gain of 3 dB is achieved when 80 mA is applied on both gate and booster SOAs, corresponding to combined gain of 24 dB. Furthermore, the booster current is the most important one, since it is possible to lower the gate current to transparency (20 mA) without significantly impacting the overall gain. This is an important aspect for the energy efficiency of MCS. By varying the gate current between 0 and 80 mA, an extinction ratio of 33 dB is achieved.

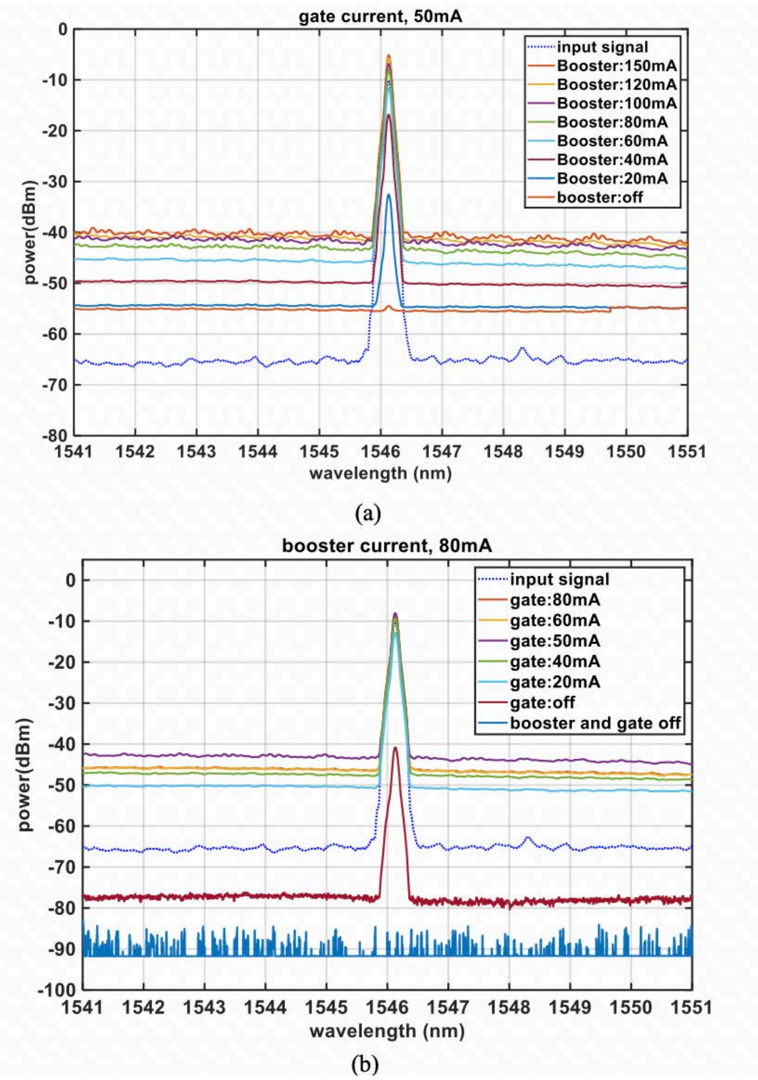


Figure 28. (a) Collected power at O4 (for path I1->O4) for varying booster current. (b) Collected power at O4 (for path I1->O4) for varying gate current.

These experimental characterizations were repeated for the remaining paths. Out of the 8 possible paths, 5 paths show expected performance as summarized in Table 1. The fibre-to-fibre transmission ranges from a gain of +2 dB to -3.4 dB when -10 dBm input power is used. The output OSNR is also monitored for two input power levels at -10 dBm and +2 dBm. The output OSNR ranges between 35 to 39 dB in case of -10 dBm input power, and 45 to 47 dB in case of +2 dBm input power. The number of waveguide crossings did not pose performance limitation, indicating the potential for successful realization of higher port count MCS. These experiments show promising prospect toward high port count and high connectivity MCS by following the modularity feature of the designs.

Table 1. Input/output connectivity and transmission performance of 2x4 MCS

Path	I/O mapping	Gate (µm)	Number of crossings	Fiber to fiber (dB) transmission @ -10 dBm input power	Output OSNR (dB)	
					Input power of -10 dBm	Input power of +2dBm
1	I1-> O4	400	3	+2	39	47
2	I1->O3	500	2	0	35	47
3	I1->O2	400	1	Not so good, -38 dB,	-	-
4	I2->O2	700	3	2 dB	37	45
5	I2->O3	600	1	+2 dB	37	47
6	I2->O1	500	4	-3.4dB	36	46

3.2.4 SOA impact on DMT-modulated PASSION signal due to node crossing

The implemented switches tested above are based on the use of SOAs. During the node crossing, the SOA can affect the system performance in case of DMT-modulated signals, such as the signals considered in PASSION network. SOA impact has been experimentally investigated at POLIMI lab with the setup shown in Figure 29. PASSION VCSEL-based transmission is analyzed, with DMT format for both dual sideband (DSB) and SSB direct modulation. The employed VERT VCSEL source emits at 1535-nm with chirp parameters $\alpha = 3.7$ and $\kappa = 1.526 \cdot 10^{13}\ Hz/W$ and equivalent electrical modulation frequency response of about 15 GHz. The electrical bandwidth of the modulating DSB DMT signal is 20 GHz with a subcarrier spacing of 78.125 MHz. A CP of 2.1% of the symbol length is added. A 100 GS/s MICRAM DAC (DAC10002) with 40-GHz electrical bandwidth and 6-bit vertical resolution generates the DMT signal. A Finisar Waveshaper (WS4000s), placed before the SOA, emulates the transfer function of a 25-GHz spacing WSS to perform an optical SSB filtering. The input power to the SOA is set between -14 dBm and 0 dBm by the cascade of an EDFA and a variable optical attenuator (VOA). The employed SOA is a 500-µm Optospeed 1550MRI/P device; Figure 30 shows the device characterization in terms of continuous-wave gain and optical signal-to-noise ratios (OSNRs) for 100-mA and 225-mA bias currents.

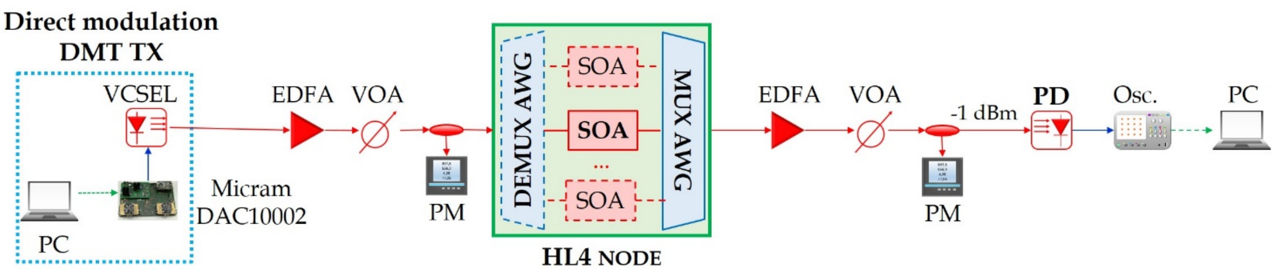


Figure 29. Experimental setup for the evaluation of SOA impact on DSB and SSB DMT signals.

PASSION

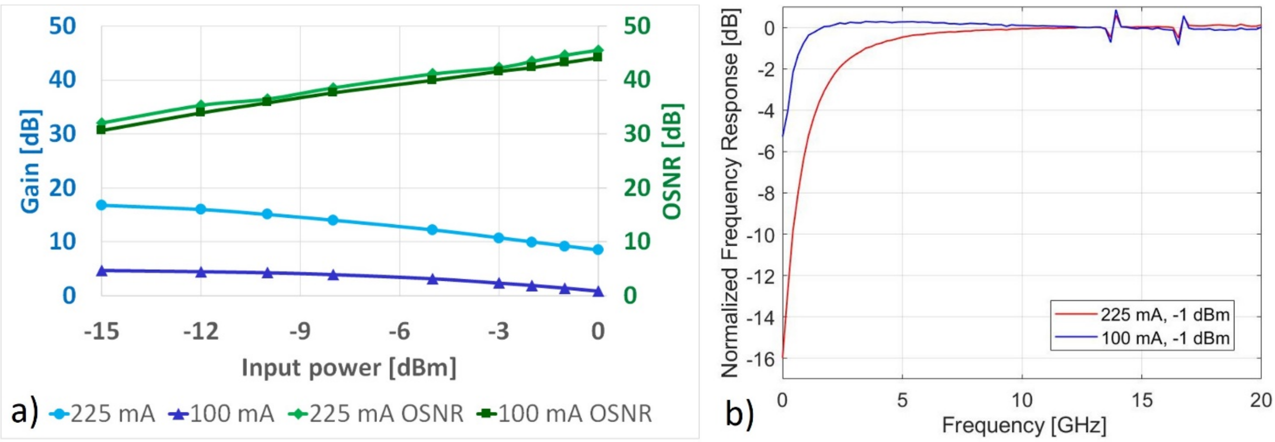


Figure 30. a) SOA characterization in terms of CW gain (blue curves) and OSNR (green curves); b) SOA transfer functions measured with a network analyser.

The bias current of the SOA ranging between these two values modifies the working conditions of the device in terms of OSNR and gain, and this directly impacts on saturation power and, therefore, on the SOA compression effect. Finally, the optical signal is directly detected by a 14-GHz PIN photodiode keeping the received power to a fixed value of -1 dBm for all the measured conditions; the received signal is then acquired by a Tektronix real-time oscilloscope with 8-bit vertical resolution, 100 GS/s and 33-GHz electrical bandwidth. Off-line processing provides digital symbol synchronization, CP removal, sub-carriers phase recovery and demodulation, and BER count. Chow's algorithm is employed to achieve optimal BL and PL for a target BER of $3.8{\cdot}10^{-3}$ (in order to exploit an advanced hard-decision FEC code with 7% overhead) and adaptively assign the appropriate bit order at each sub-carrier during the mapping procedure. The total transported capacity gives a measurement of the system performance for several SOA bias currents and input optical powers.

Figure 31 shows the dependence of the measured capacity on the SOA OSNR in case of a) DSB modulation and b) SSB modulation. For both the modulations, the capacity increases with the measured OSNR (i.e., with the input optical power) till a given OSNR value of approximately 42 dB (corresponding to an input optical power ranging between -4 dBm and -2 dBm for different bias currents) for bias currents higher than 150 mA.

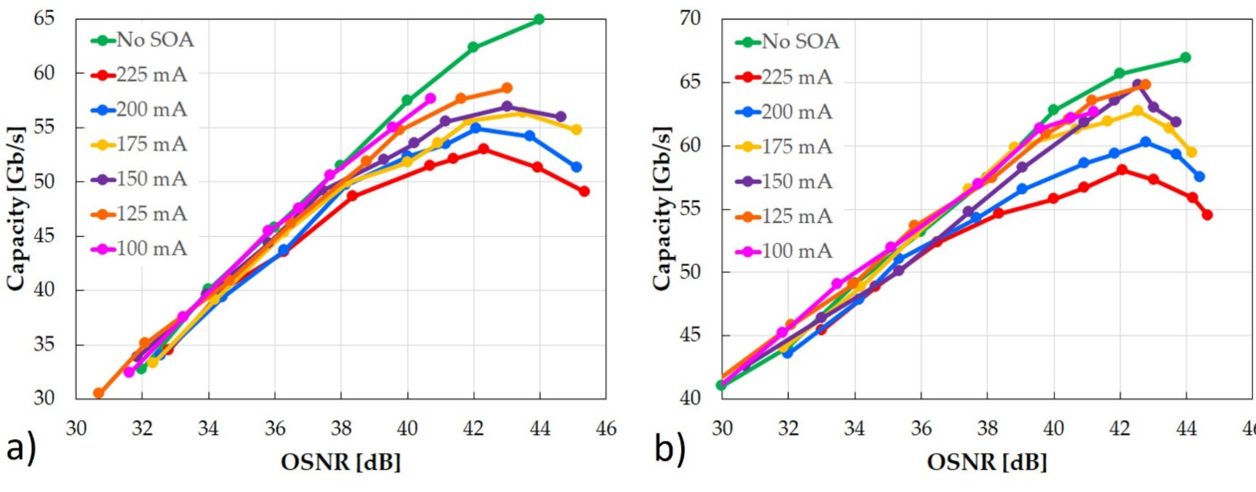


Figure 31.Transmitted capacity for a) DSB modulation and b) SSB modulation when a single SOA is crossed.

When the power is further increased, the capacity decreases. This is due to a significant gain compression caused by self-gain modulation (SGM), which causes the electrical transfer function of the SOA to act as a high-pass filter, as shown in Figure 31b). The high-pass filtering impairs the low-frequency subcarriers, which can be loaded with lower-order modulation formats, and this decreases the maximum achievable capacity. The magnitude and the width of the low-frequency notch strictly depend on the optical power at the output of the SOA, i.e., on the SOA gain and input power: lower bias currents and/or input optical powers reduce the high-pass filtering effect, increasing the transmitted capacity with respect to highly-saturated conditions. The gain compression causes the high-power capacity at 225 mA to be reduced of 17 Gb/s for DSB modulation and of 13 Gb/s for SSB modulation with respect to the corresponding capacities in absence of the SOA. In the low-bias regime, the most impacting factor on the achievable transmitted capacity is the ASE noise introduced by the amplifier, as visible in Figure 31: for low OSNR values, the capacities approach the ones obtained in absence of the SOA for all the bias currents.

The optimal performance is a trade-off between the ASE noise generated by the SOA, which causes a reduction of the OSNR, and nonlinear impairments, such as SGM, which cause distortions in the DMT optical signal. For DSB DMT modulation, the target capacity of 50 Gb/s can be achieved for an OSNR value around 38 dB, corresponding to -8 dBm optical power for bias currents higher than 125 mA. For SSB modulation, the same target capacity is obtained for 34/35 dB OSNR, widening the operation range to -10 dBm input power. Moreover, the capacity at low input power is increased by 30% when the VCSEL is modulated with the 20-GHz SSB with respect to a DSB signal with the same electrical bandwidth. In general, also considering the BTB case, SSB DMT direct modulation is more resilient to the introduction of noise and of nonlinear impairments such as SGM, thanks to a lower carrier-to-signal power ratio, defined as the ratio between the powers of the unmodulated carrier and of the modulating signal [Rapis20].

As also evidenced in the previous paragraph the choice of the SOA conditions in terms of bias current is of paramount importance for the operation of the PASSION node switches. Moreover, from a system performance perspective when adopting a multicarrier modulation format such as DMT the right choice of bias current and input power assures a trade-off between OSNR and nonlinear impairments, preserving the maximum transported capacity, close to the reference value measured in BTB without node crossing. This is very promising for the adoption of the whole PASSION S-BVT and switching modular architecture.

3.3 Photonic space switch Assessment

ETRI and Chem Optics have developed the 16x16 optical matrix switch structure based on the polymer optical waveguide, operating as photonic space switch in the PASSION switching/aggregation node. The high thermo-optic effect of polymer material is exploited to form a simple switch as the unit optical switch elements. The conceptual switch structure is shown in Figure 32. 16 input waveguides and 16 output waveguides are crossing etch other to make 256 cross points, and there is a unit switching element at each crossing point. The unit switching element is a total internal reflection (TIR) switch which is just a waveguide crossing with a heater on it.

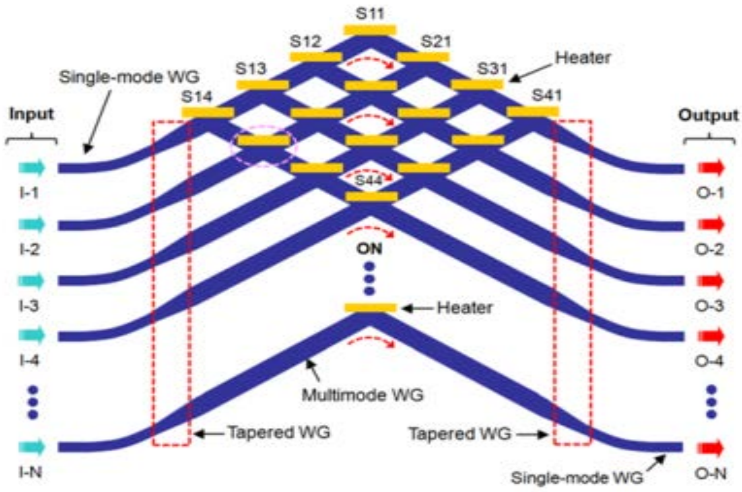


Figure 32. Conceptual diagram of 16x16 matrix switch structure.

In the switch structure the shallow ridge polymer waveguide has been adopted as in Figure 33.

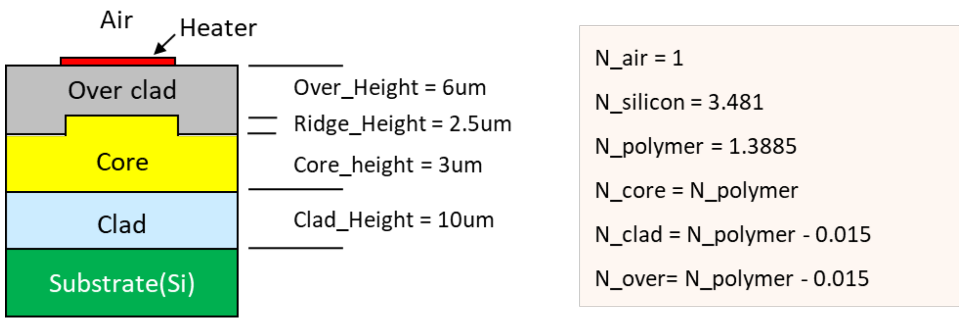


Figure33. Shallow ridge polymer optical waveguide structure.

ETRI and CHEM optimized the TIR structure design as follows.

- Crossing Angle of waveguides 8°
- Multimode (MM) Waveguide Width for TIR switch 42μm
- Single mode (SM) waveguide Width 7μm
- SM to MM conversion Taper Length 2600μm
- Heater width 6μm, Heater Offset 8μm

They also have confirmed the switching operation of our TIR design using BPM as shown on Figure 34. About 50 degree difference of heater temperature causes nearly perfect switching in the TIR.

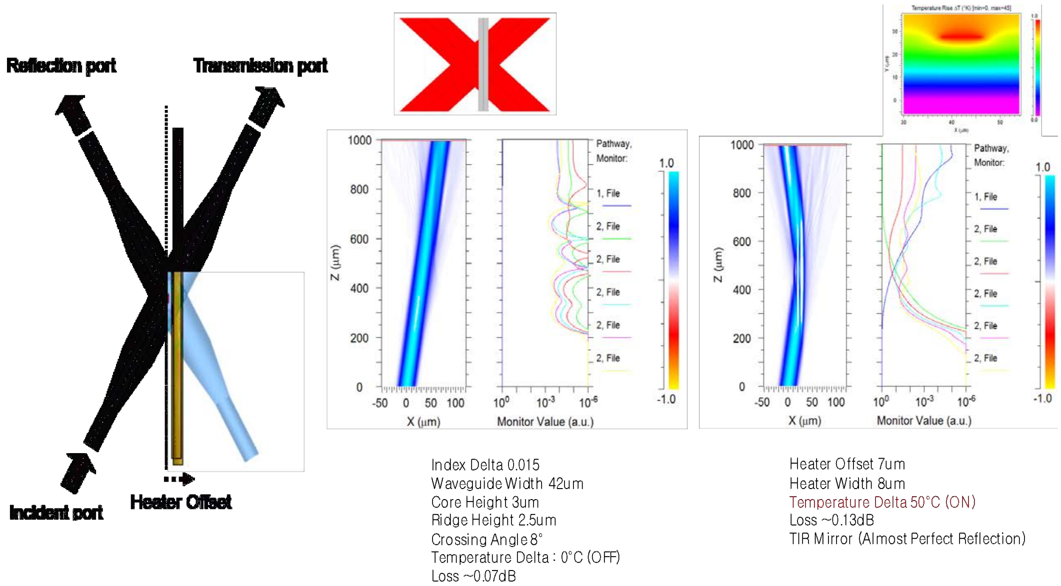


Figure 34. BPM simulation of the shallow ridge TIR switching element.

To fabricate the 16x16 matrix switch chip, ETRI and CHEM need the standard spin coating process of polymer materials, the photo-lithographic and etching processes are shown in Figures 35 and 36.

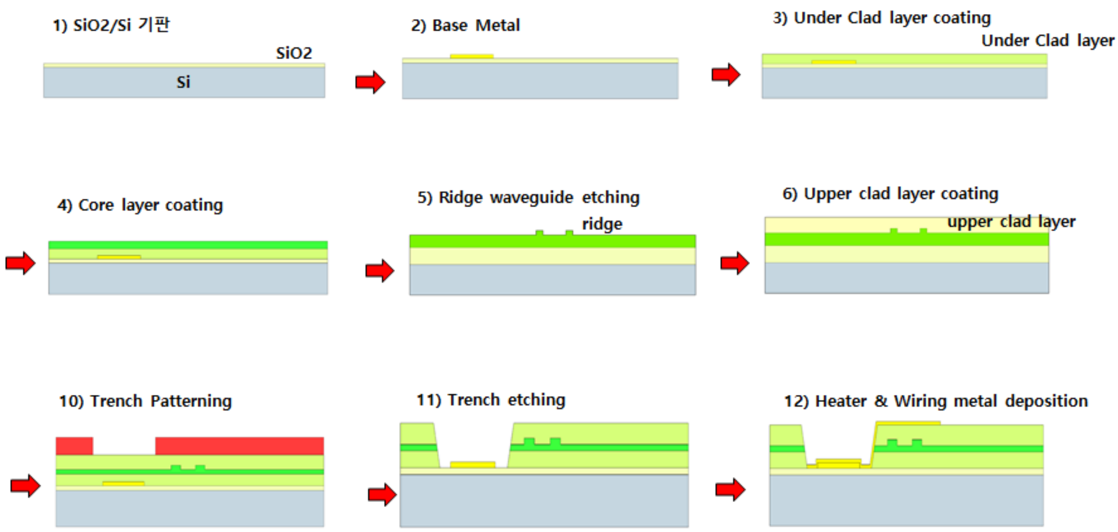


Figure 35. Fabrication process of polymer matrix switch chip.

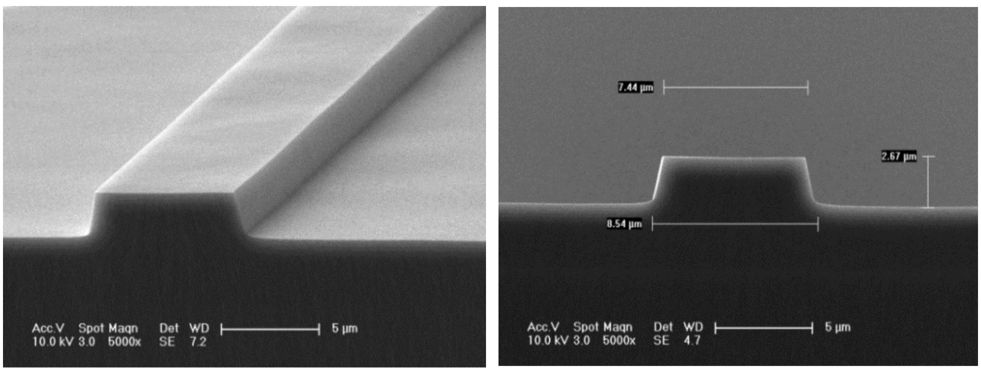


Figure 36. Etched polymer ridge.

We obtained the following characteristics:

- Wafer 4in diameter, 1mm thick silicon with 0.5μm thermal oxidation layer
- Polymer material Chem Optics LFR 725 Series
- Refractive index of polymer 1.372 for upper and lower clad, 1.387 for core
- Index delta 0.015 (1.1Δ%)
- Heater Material Cr-Au 2500A

The 16x16 matrix switch chips are diced, the additional glass lids are bonded on both edges of the chip, as shown in Figure 37.

This 16x16 matrix switch chip need to be evaluted before being pigtailed and packaged. We automised the measurement process of the switching properties using a programmable motion stage. In Figure 38, the typical switching properties of our 16x16 matrix switch chip are shown.

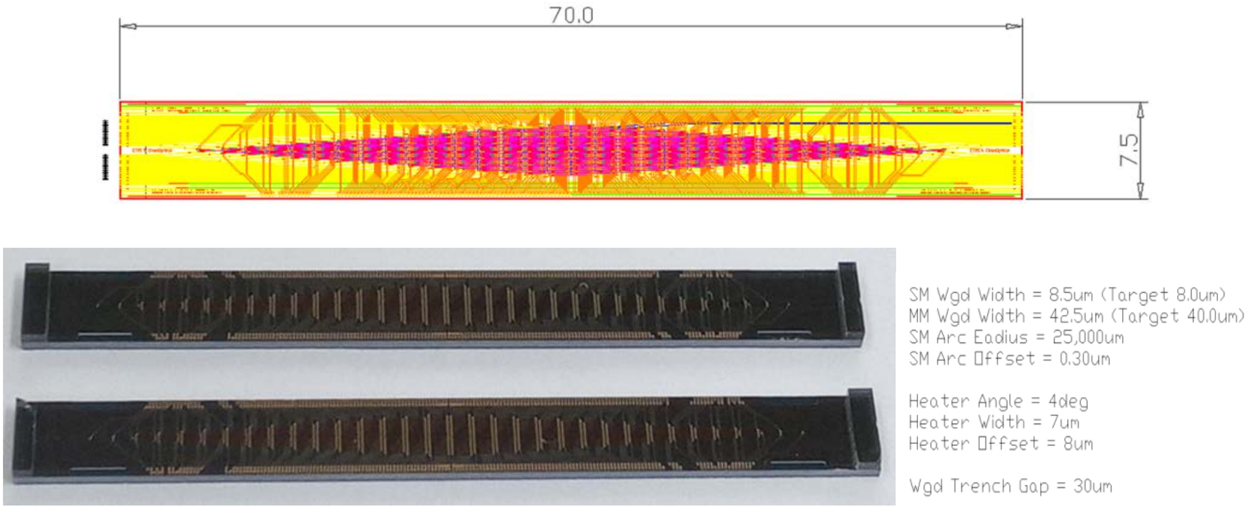


Figure 37. The 16x16 matrix switch chips.

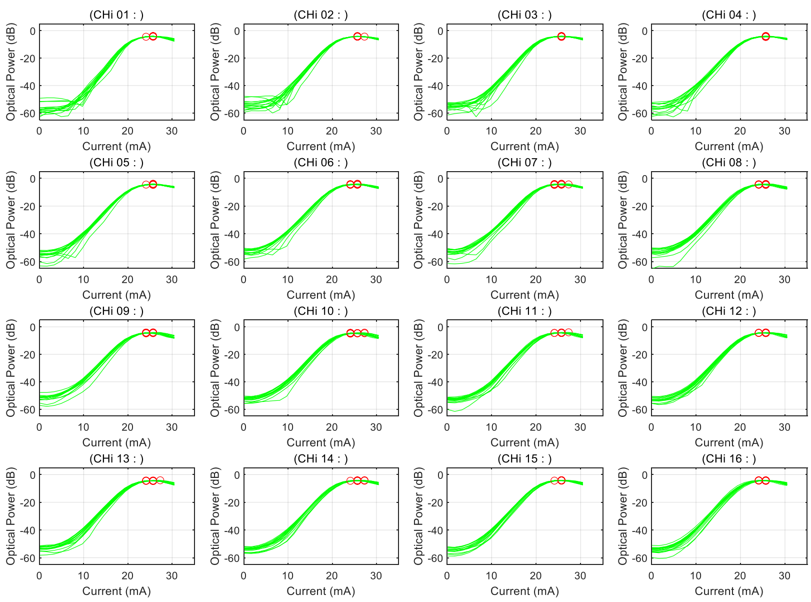


Figure 38.Typical switching curve for all 256 switching elements in the 16x16 matrix switch chip.

The final data of our 16x16 matrix switch chip can be summarized as follows:

- Average Switching Current 26mA
- Switching Power of unit TIR 34mW
- Insertion Loss after full package < 5dB
- Extinction > 45dB
- Polarization Dependent Loss < 0.5dB

3.4 Photonic Space Switch Integration

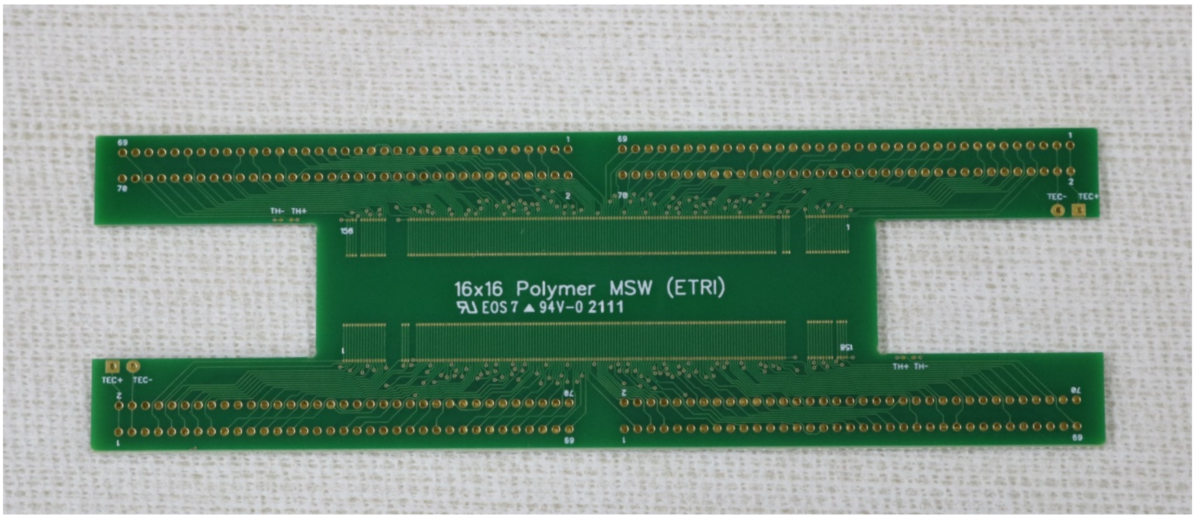
3.4.1 16x16 polymer matrix switch integration

One of the objects of the PASSION project is the packaging of the large port photonic space switch constituted by the 16x16 polymeric matrix switch, for the system demonstration. The integrated module structure has to satisfy:

- Electrical connection of 475 contact pads (16x16 polymer switch chip contains 256 switching elements)
- Optical connection of 16 input and 16 outputs
- Temperature control of switch photonic chip (integration of TEC & thermistor)
- Stable integration of large size photonics chip (70 x 7.5 mm^2)

Flip chip bonding can connect large number of electrical pads and may lead to smaller packaging size. However, high flip-chip process temperature and large contact chip area may limit the application of flip-chip technology to polymer waveguide photonic chip. Therefore, ETRI attempted both the flip-chip bonding method and the wire bonding method.

The 16x16 polymer matrix switch photonics chip is flip-chip bonded to PCB board to avoid numerous wire bonding. Figure 39 shows the picture of the 16x16 polymer matrix switch chip and the corresponding PCB.



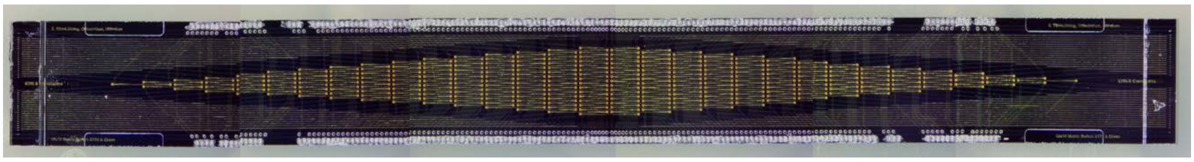


Figure 39. 16x16 polymer matrix switch chip and corresponding PCB.

High density flip-chip bonding contact points (0.19 mm open pad width, 280μm pitch) in 48.45 mm long contact pad length made flip chip bonding process fastidious. Small size of T5 and low melting temperature of 160°C SnBi solder is used to minimize the high temperature damage to polymer material. The solder is screen printed to the chip side in wafer scale and stud bump is applied to the PCB side. An optimized amount of screen-printed solder prevents the short of the electrical path while stud bump firmly contacts the solder on the opposite side. An average resist of 0.6 Ω is added to one flip-chip bonding contact. A microscope image of printed solders on the switch chip and stud bumps on the corresponding PCB are shown in Figure 40.

The polymer switch photonics chip is covered with the CuW Jig to support the structure stiffness. The CuW Jig: (1) supports PCB not to bend, (2) prevents external mechanical damage during packaging process and (3) works as heat sink. As shown in Figure 41, the flip-chip bonded 16x16 polymer switch chip with guard JIG is packaged.

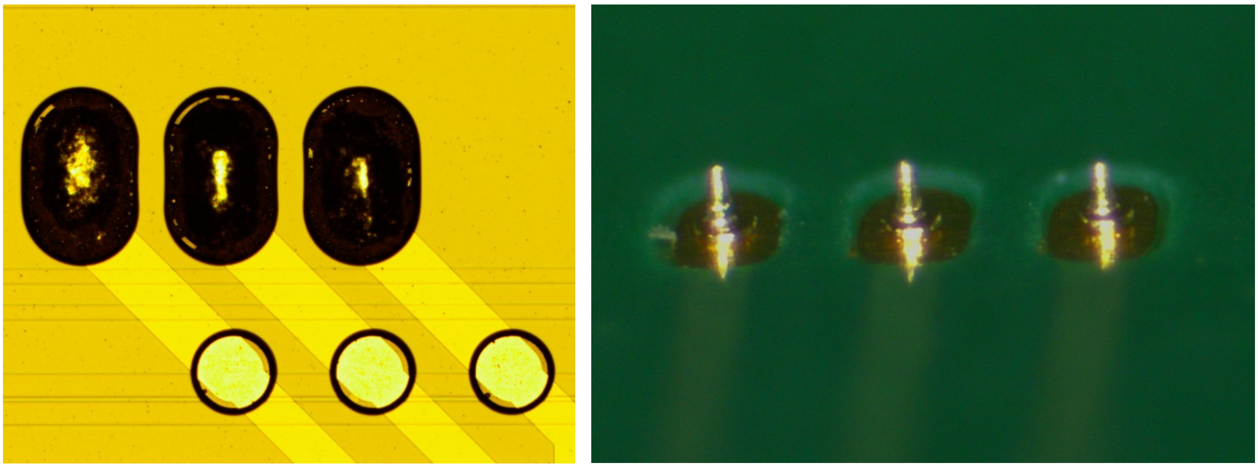


Figure 40. A microscope image of screan printed solders on the switch chip and stud bumps on the corresponding PCB.

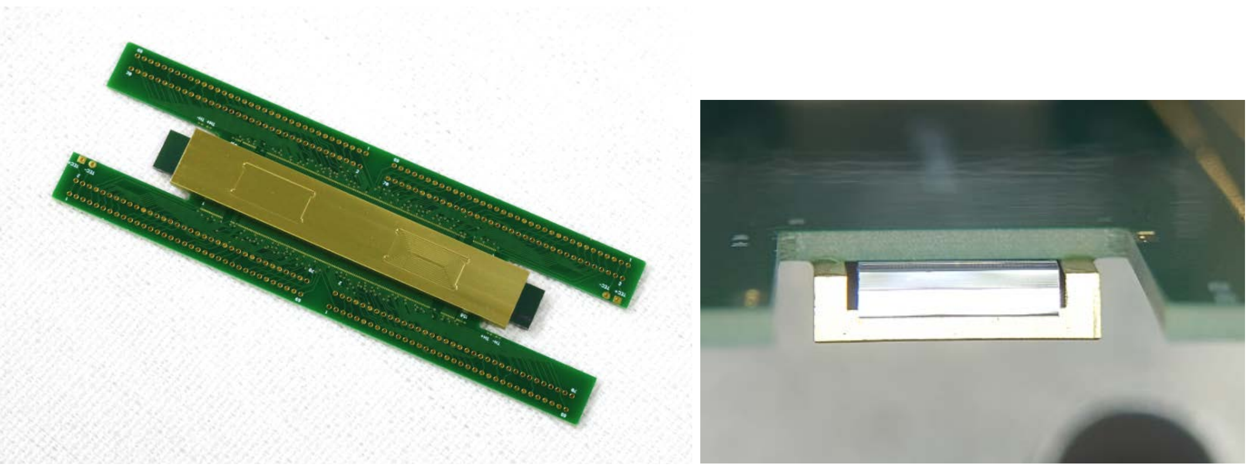


Figure 41. Flip-chip bonded 16x16 polymer switch chip with guard JIG (top view, side view).

The 16x16 matrix switch package consists of a matrix switch chip, a 16-ch fiber array block, a switch chip holder, TEC & Thermistor, the package case, a header pin, a sub PCB as shown in Figure 42. TEC and thermistors are attached to the switch chip holder which works as heat sink. The package components are compatible with both flip-chip bonding type PCB and wire bonding type PCB.

The prototype of 16x16 matrix switch module is assembled as in Figure 43. In order to secure the semi-hermetic reliability of the prototype, a humidity getter is attached to the lid of the case, followed by a nitrogen filling and sealing process to complete the assembly.

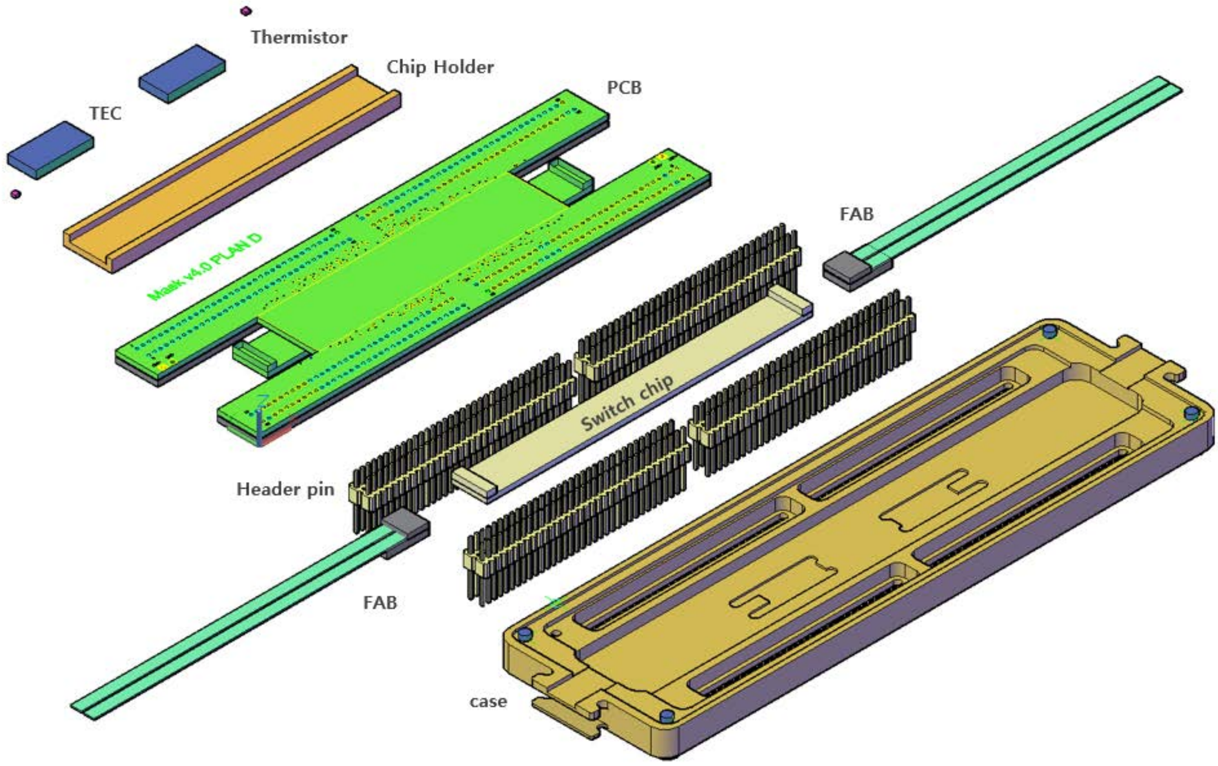


Figure 42. Components of 16x16 matrix switch package module.

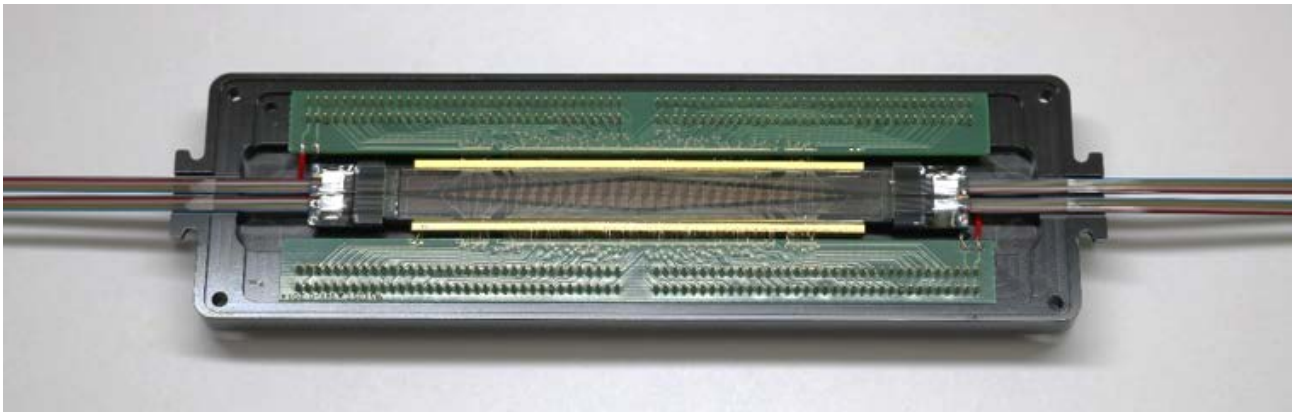


Figure 43. The prototype of 16x16 matrix switch module.

3.4.2 16x16 polymer matrix switch controller

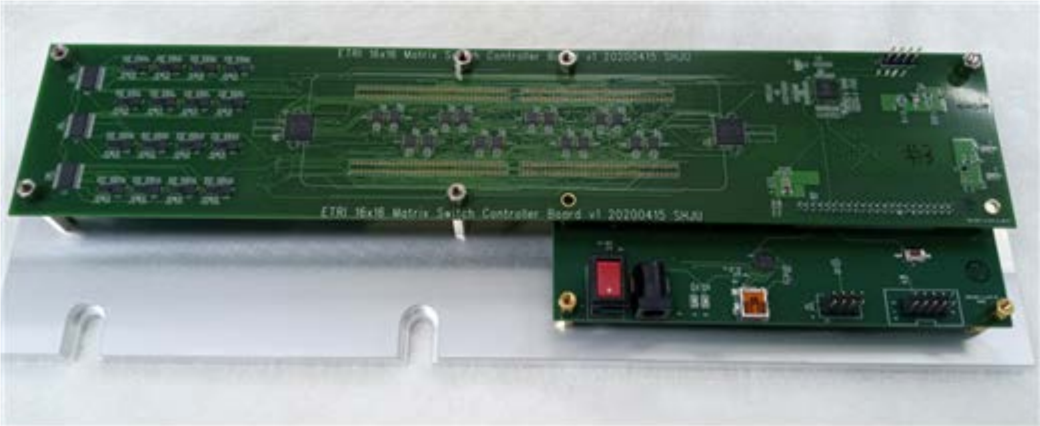


Figure 44 Picture 1 16x16 matrix switch controller

ETRI spent effort to build a test environment around 16x16 polymer based spatial switch. More specifically, on top of a mechanical support small control board (Figure 44) has been developed with the purpose to control the device. Main features of control board are:

- Variable Constant Current Driver (max 200mA, 3.5V) with +5V input
- TEC Controller included
- Host (Line Card) to Controller: Standard I2C communication
- USB to UART communication (COM port for debug)
- Switch driving voltage & current monitoring
  16 (Current Source) + 16 (Mux Switch) => 256 TIR Switch Control
- TEC temperature, voltage & current monitoring

256 polymer matrix switching elements working conditions are:

- Typical operation current: 20 mA
- Maximum operation current: 40 mA
- Maximum applied volatage on single heater: 3V

To control 16x16 matrix switch, 256 switching elements must be controlled with efficient current control driver. Each switching elements may have different loading resist caused by different electric wire length and characteristics of switching element. Therefore, constant current source is used in the switch controller to maintain constant current independent from the loading resist. LT3092 IC (from Linear Technology Corp.) and AD5206 Digital Potentiometer IC (from Analog Device Corp.) are used to program and control the 256 separate currents. The block diagram and current driver chipset configuration of 16x16 switch controller is shown in Figure 45.

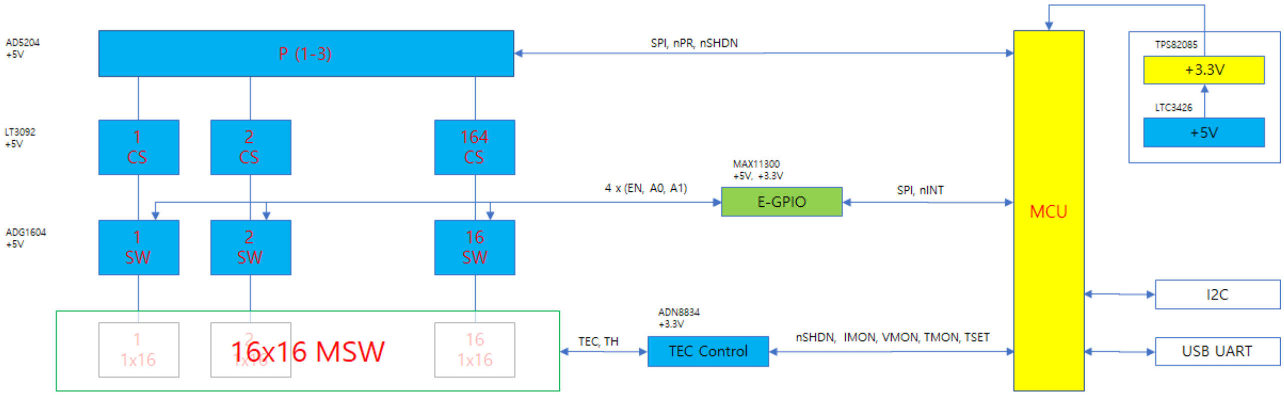


Figure 45 Block diagram of switch controller

16x16 matrix switch is consist of sixteen 1x16 switch, therefore sixteen of 1x16 switch controllers are needed for full matrix switch controller. *Figure 46. Current driver chipset configuration of 16x16 Switch controller*shows simple current driver chipset configuration.

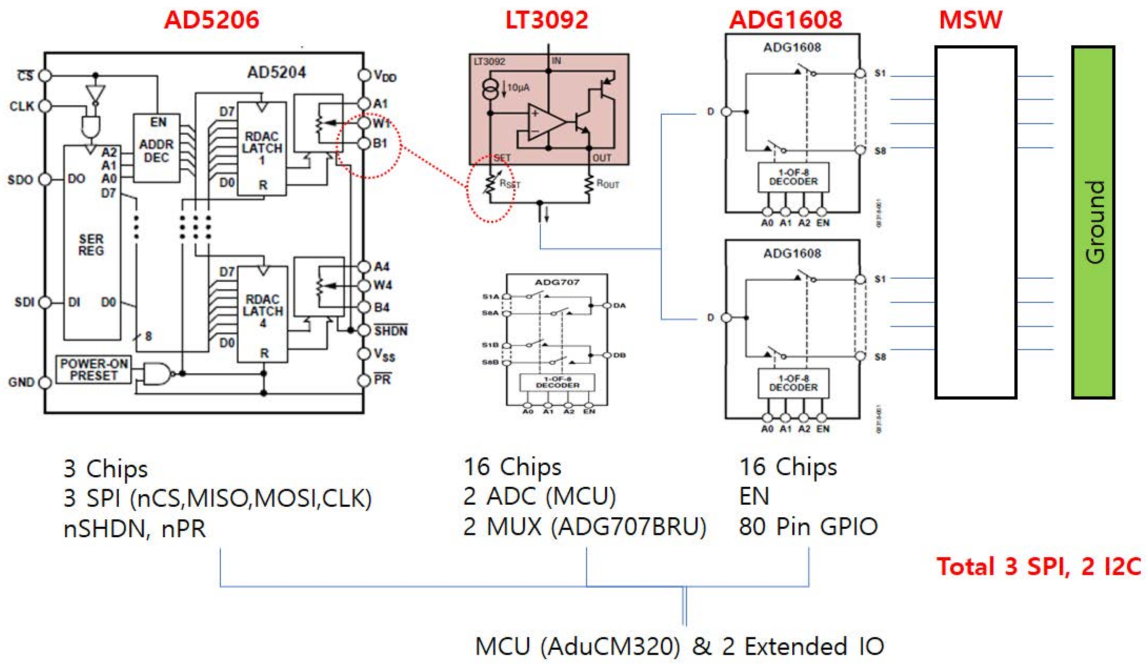


Figure 46. Current driver chipset configuration of 16x16 Switch controller

In the early stage, one current source with two 1x4 MUX switch was basic concept. However, separate GND was needed for 256 switching elements and complex electrical wiring with small footprint became issue. To solve the problem, common ground is applied to the switch and the controller driver to minimize the contact points. 512 +α ea contact points are minimized to 256 +α ea, which is nearly 50% decrease (Figure 47).

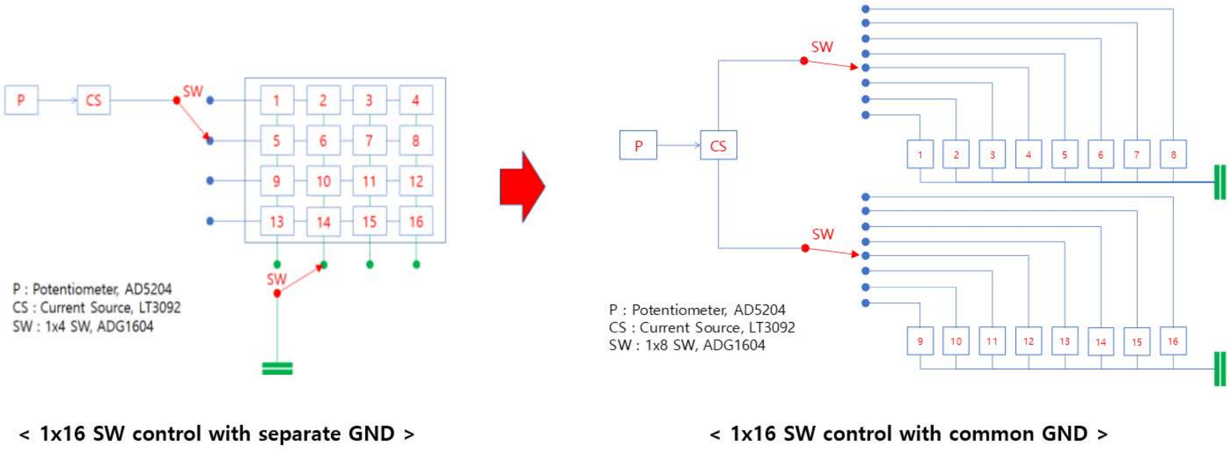


Figure 47. 1x16 MUX switch wiring concept

ETRI integrated controller board MCU AduCM320 (from Analog Device Corp.) with the 16x16 switch controller and controller board Firmware was programmed togther. Firmware program controlls and monitors the switch controll board. The functions of firmware are listed as:

- Controll current of 16x16 matrix switch
  - Set up the current level of sixteen constant current soucre
  - Set up TEC temperature
  - Set up the limmitiation of maximum TEC current value
  - Set up matrix switch path
- Monitor the board operation
  - Monitoring of Power Voltage
  - Monitoring of applied current of each switch
  - Monitoring of TEC temperature
  - Monitoring of TEC current and voltage
- Alarm Function
  - Module not ready alarm (Temperature control not ready)
  - Current and Voltage error alarm

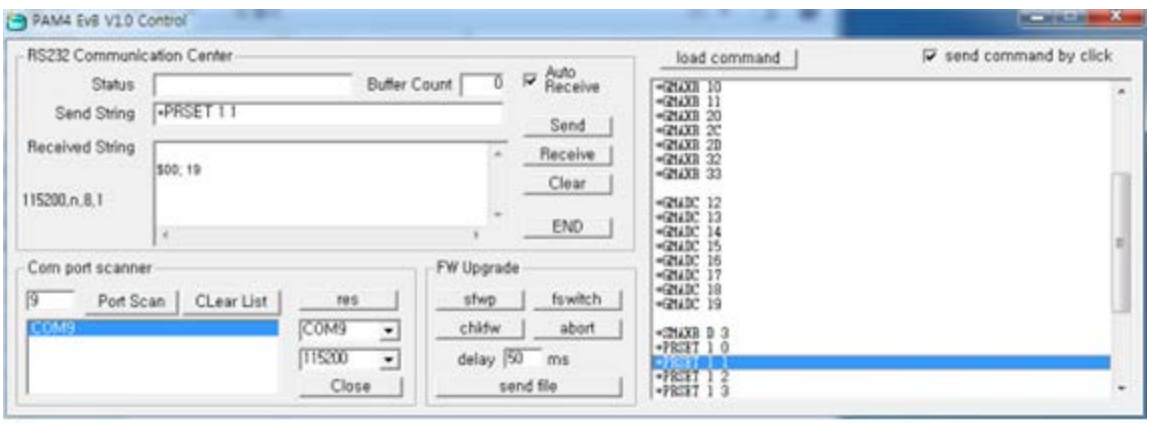


Figure 48. Graphic User Interface program for debug

Graphic User Interface (Figure 48) is programmed together based on Visual Basic program and matrix switch commands are listed in 2.

Table 2. List of Matrix Switch controll Command

Command		Syntax	Description
0	RES	*RES[CR]	Software System Reset
21	LED	*LED[SP]SW[CR]	Test LED On/Off/Toggle
22	GADC	*GADC[SP]CH[CR]	Get MCU ADC Volatge
23	SVDAC	*SVDAC[SP]CH[SP]V[CR]	Set MCU VDAC Voltage
24	GVDAC	*GVDAC[SP]CH[CR]	Get MCU VDAC Setting
26	RDGP	*RDGP[SP]P[CR]	Read GPIO Port Value
27	RDGPP	*RDGP[SP]P[CR]	Read GPIO Port Pin Value
28	WRGP	*WRGP[SP]P[SP]DT[CR]	Write GPIO Port Value
29	WRGPP	*WRGP[SP]P[SP]DT[CR]	Write GPIO Port Pin Value
31	ENCS	*ENCS[SP]SW[CR]	Enable +5V CS Power
46	PRSET	*PRSET[SP]CHIP[SP]CH[SP]R[CR]	Set Potentiometer (kΩ)
41	MUXA	*MUXA[SP]CH[CR]	Set MUXA Channel
42	MUXB	*MUXB[SP]CHIP[SP]CH[CR]	Set MUXB Channel
43	FINDSL	*FINDSL[CR]	FIND I2C Slave Address
44	RDEIOR	*RDEIOR[SP]CHIP[SP]ADDR[CR]	Read EIO Register
45	WREIOR	*WREIOR[SP]CHIP[SP]ADDR[SP]DT[CR]	Read EIO Register
46	RDEIOP	*RDEIOP[SP]CHIP[SP]PORT[CR]	Read EIO Port Register
47	WREIOP	*WREIOP[SP]CHIP[SP]PORT[SP]DT[CR]	Read EIO Port Register
51	ENTEC	*ENTEC[SP]SW[CR]	TEC Driver On/Off/Toggle
52	STEMP	*STEMP[SP]T[CR]	Set TEC Temperature
53	RTEMP	*RTEMP[CR]	READ TEC Temperature
54	GTEMPS	*GTEMPS[CR]	Get TEC Temperature Setting
55	RTECI	*RTECI[CR]	Read TEC Current
56	RTECV	*RTECV[CR]	Read TEC Voltage
57	TECREF	*TECREF[SP]V[CR]	TEC V Limiting Reference
61	SCSI	*SCSI[SP]CH[SP]I[CR]	Set CS Current
62	SCSIA	*SCSIA[SP]I[CR]	Set CS Current All
63	RSWI	*RSWI[SP]CH[CR]	Read SW Current
64	RSWV	*RSWV[SP]CH[CR]	Read SW Voltage
65	SPATH	*SPATH[SP]DT[SP]DT[SP]DT[SP]DT[CR]	Set SW Path
66	GPATH	*GPATH[CR]	Get SW Path Setting
	SCSI8	*SCSI8[SP]I[CR]	Set 8 CS current, others set to
	S8P	*S8P[SP]DT[SP]DT[CR]	Set 8x8 SW Path
	G8P	*G8P[CR]	Get 8x8 SW Path Setting
80	COMTST	*COMTST[CR]	Communication Test

Figure 49 shows 16x16 polymer matrix switch module monted on the controller board. 16x16 matrix switch is fully controlled and monitored via the controller board. To test and debug the switch controller board, USB to UART converter chip integrated communication board is additionally developed. The 16x16 polymer switch interface is Samtec 4 x TMS-135-01-G-D (total 280 pins) pin socket and controller board interface is 2mm pitch 44 pin socket. The interface pin definitions for controller board are provided in **Error! Reference source not found.**3 and the dimension of the controller bard and communication board are shown in Figure 50.

Figure 49. 16x16 polymer matrix switch monted on the controller board.

Table 3 Controller Board interface pin discription.

Pin No.	Pin Name	Description
1	VIN (+5V)	Power (+5V)
2	GND	Ground
3	VIN (+5V)	Power (+5V)
4	GND	Ground
5	READY	Ready for next command
6	ALARM	Alarm while executing the previous command
7	MCU_nRST	MCU reset (active low)
8	SWIO	Pins for programming the MCU (ADuCM320)
9	SWCLK	
10	TXD	UART TXD pin (connect to host RXD)
11	RXD	UART RXD pin (connect to host TXD)
12	I2C_SDA	I2C data (internally pull-uped)
13	I2C_SCL	I2C clock (internally pull-uped)
14~42	NC	not connected, Actually you may use 14 pin socket
43	VIN (+5V)	Power (+5V)
44	GND	Ground Internally connected

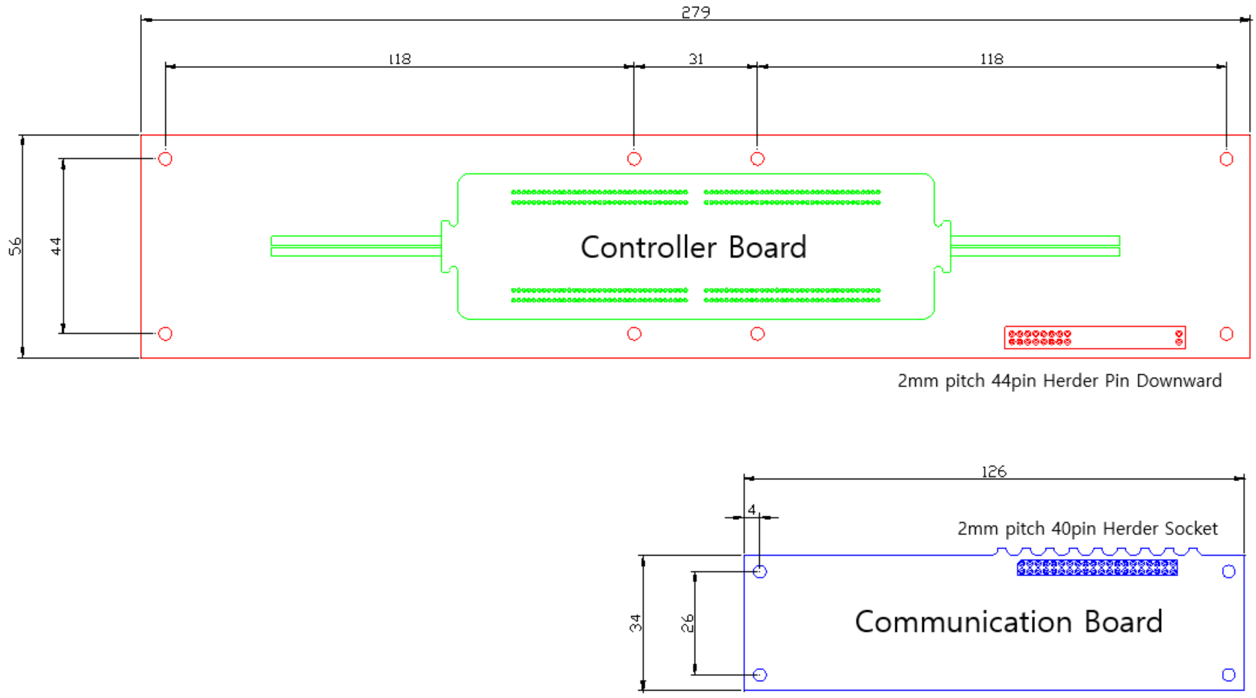
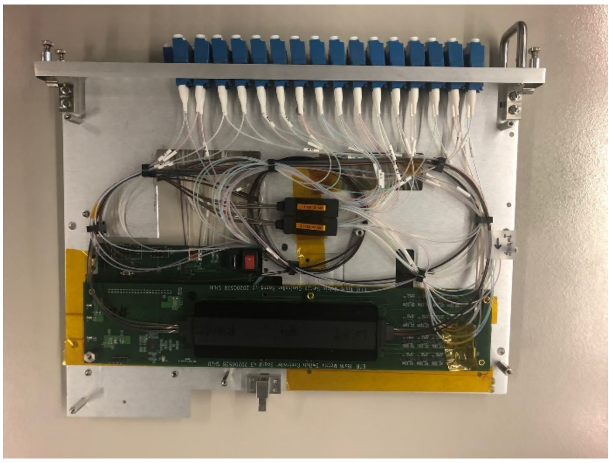


Figure 50. Controller Board and Communication Board Dimension.

3.4.3 16x16 switch mechanical integration in SMO Subrack

Starting from the prototype delivered by ETRI, SMO performed a study to mechanically integrate the device within a LM1-WDM subrack, reusing optical connectivity already present on the front panel for other applications. Figures 51 and 52 show the obtained result.



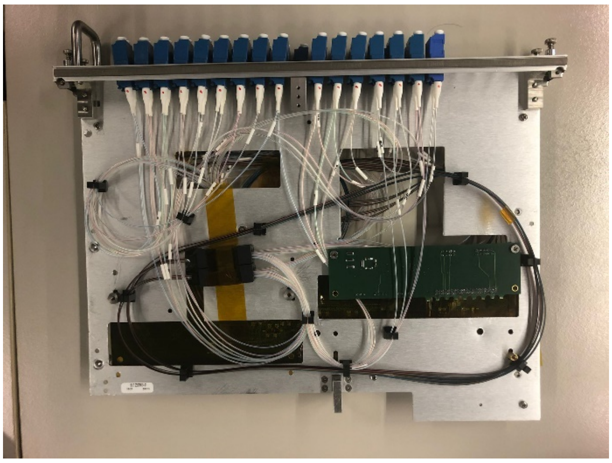


Figure 51. 16x16 Spatial switch integrated in a standard 300mm ETSI subrack (top and bottom view)

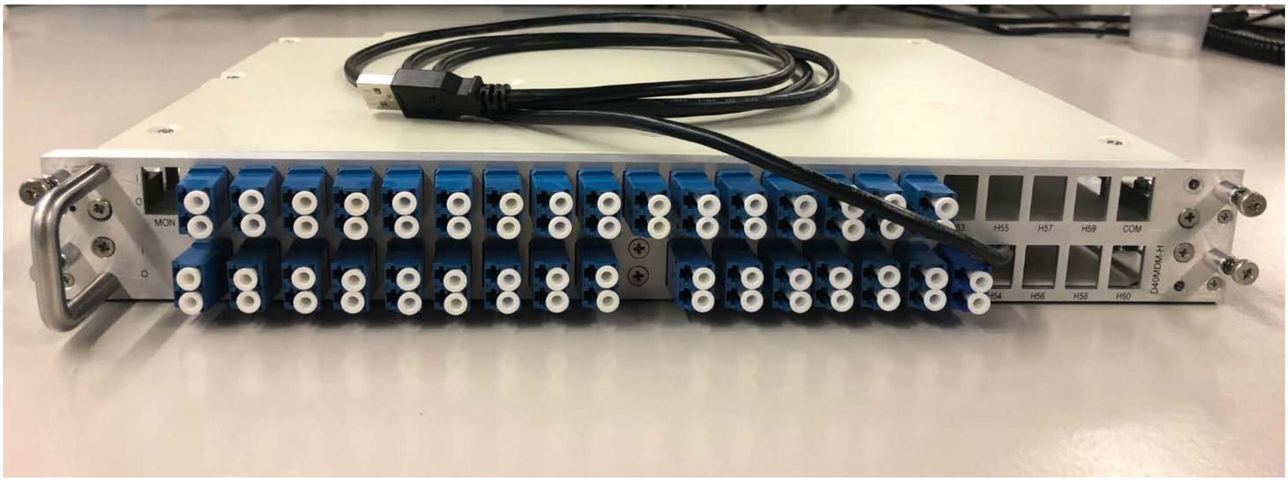


Figure 52 16x16 Spatial switch integrated in a standard 300mm ETSI subrack (front view)

3.4.4 Photonic space switch integration in CTTC lab-trial

The 16x16 polymer matrix switch provided by ETRI, was sent to CTTC premises in Dec'20, in order to be integrated within the experimental set-up at data plane level, including the ADRENALINE network, and other elements (e.g., S-BVTx, S-BVRx, multicore fibers - MCFs). CTTC started to operate the polymer matrix switch with the support of ETRI, provided during virtual training session. The polymer switch was installed on the optical table in the CTTC laboratory, connected to the required external power supply and serial cable to configure it from a PC with the 16x16 SW v3.0 Board Control GUI installed. The operation of the switch was tested by sending commands to access I2C registers. For the correct operation, ETRI sent to CTTC technical details about the sequence of instructions to configure the switch, and also the list of failed channels. During the preliminar tests at CTTC premises, some optical signals were connected to different ports of the switch matrix. It was observed that the switch was working correctly, according to the measured data report sent by ETRI.

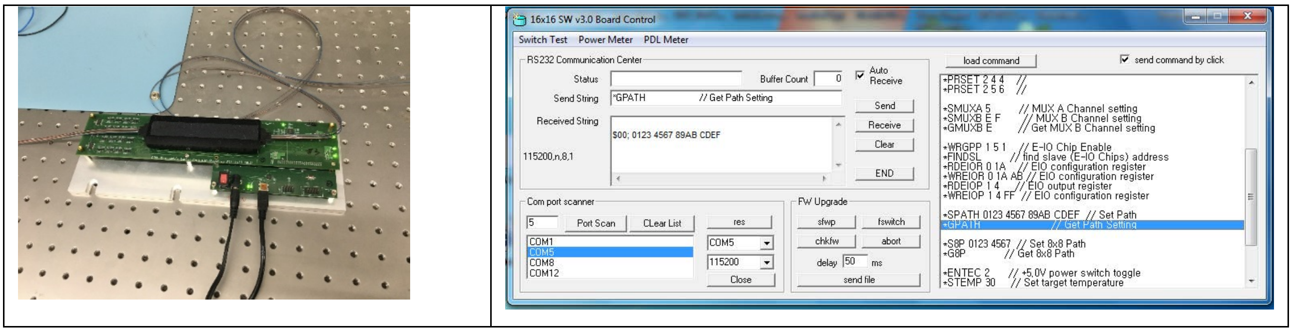


Figure 53. Integrated 16x16 space matrix switch (left). The system configuration.

Then, the 16x16 switch matrix was integrated and tested in the CTTC ADRENALINE testbed (Figure 53), enabling spatial switching in the developed set-up. This has been demonstrated in the contribution that will be presented in the demo zone of the conference OFC 2021 (M. Svaluto Moreolo et al. "Demonstration of an SDN-enabled VCSEL-based Photonic System for Spectral/Spatial Connectivity in Disaggregated Optical Metro Networks").

4 PASSION Coherent Receiver assessment and integration

4.1 Coherent Receiver Assessment

A fully integrated CRX PIC design was made in HHI's MPW platform (Fraunhofer Heinrich Hertz Institute Multi-Project Wafer Run offering, n.d.). This technology allows to integrate lasers, passive splitters, polarization handling and spot-size converters in a single chip. Figure 54. shows the design of the chip and highlights some of the major parts. On the righthand side an array of four spot size converters (SSCs) take a 10 µm standard fiber mode and transform it down to a 2 µm waveguide mode. The SSCs are 250 µm apart, which facilitates coupling to standard fiber arrays. The top fiber is used to calibrate the on-chip Local Oscillator (LO). Alternatively, this fiber can also be used to launch an off-chip LO as a fallback option in case the on-chip LO does not function. The third fiber from the top is the main input, which accepts a polarization multiplexed signal. For mitigation in the design stage, a X bypass and Y bypass are included. These can be used when the polarization splitter and rotator on the chip are not meeting specifications. To be able to use these bypasses an external polarization rotating beam splitter is needed, combined with a polarization maintaining fiber array.

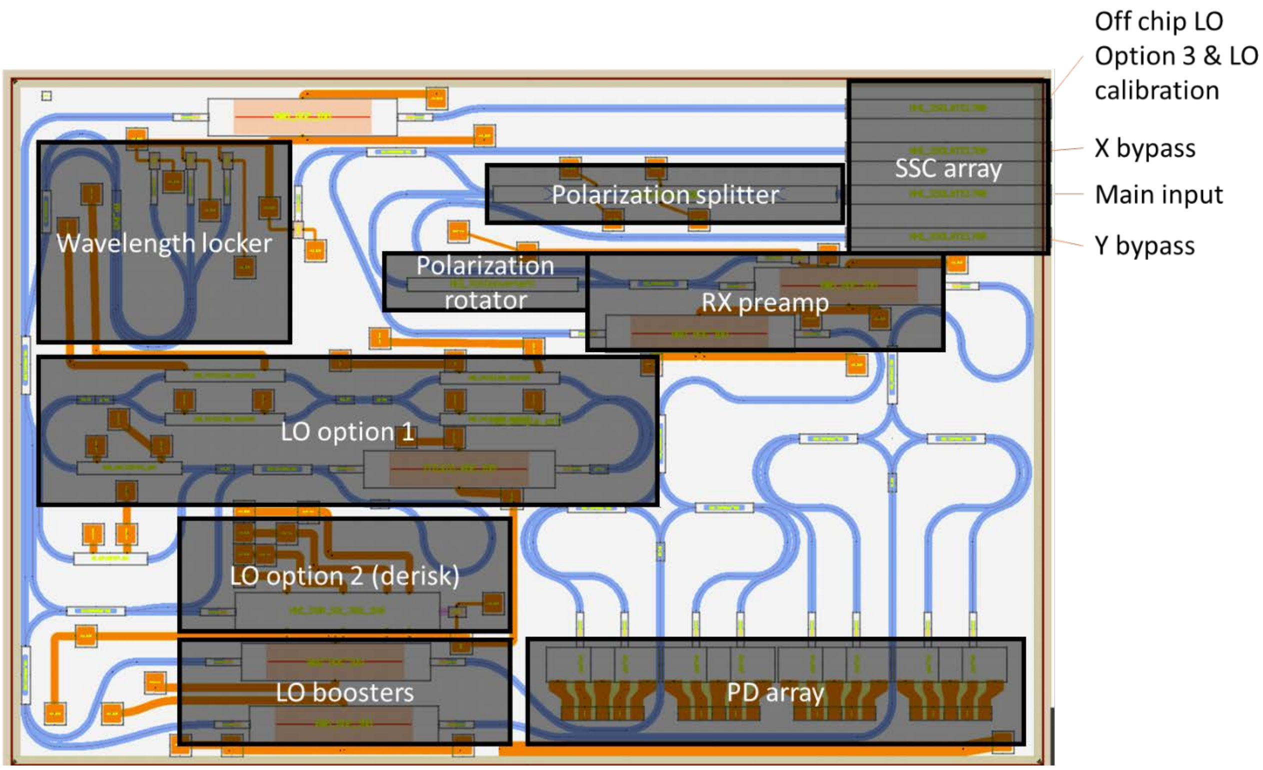


Figure 54. CRX photonic integrated circuit design.

After fabrication, the PIC was first characterized by looking at the performance of individual components. Testing began by first verifying the electrical IV response of all the diodes and resistors that are integrated on the chip. Figure 55. 55 shows the measured current voltage relation for all the diodes. This testing shows diode like behavior for all the diodes, but with a higher series resistance than expected. This is likely due to a fabrication issue. As Figure 56. 6 shows all integrated resistors demonstrate the expected linear current-voltage relationship, apart from a single instance.

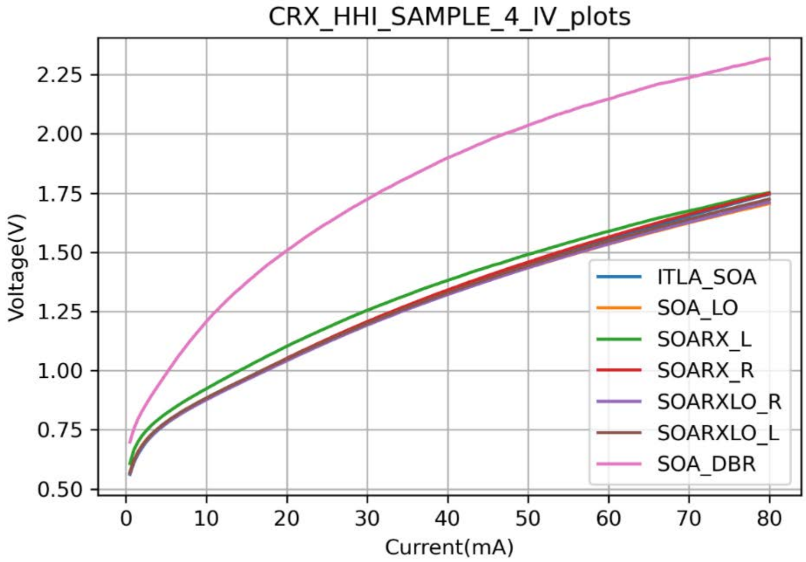


Figure 55. IV measurement of the Semiconductor Optical Amplifiers (SOAs).

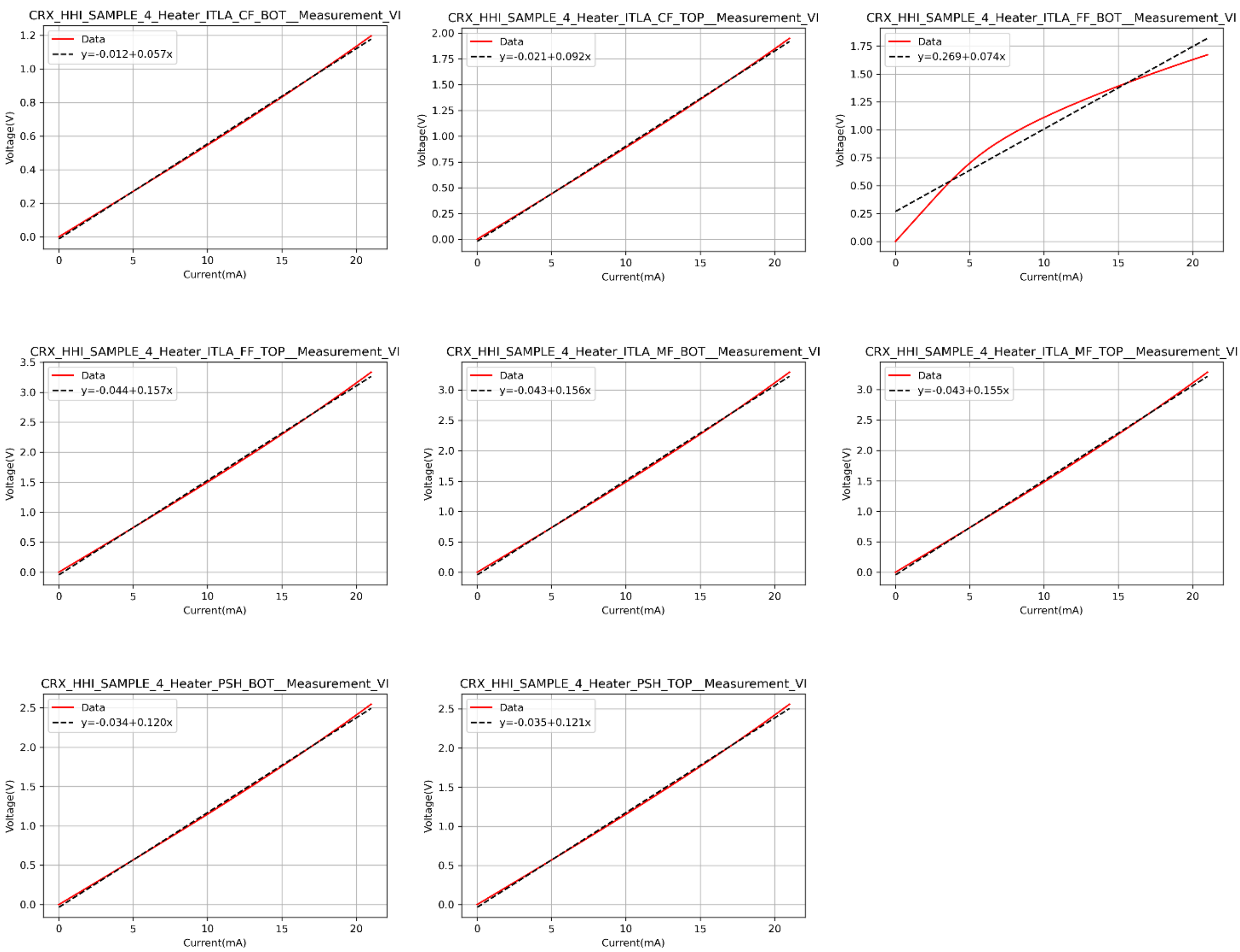


Figure 56. IV plots of the heater-based structures.

After electrical testing, electro-optic testing was performed. The following electro-optic components were tested individually: the LO, the polarization splitter, and SSC array. The LO was measured first. The main performance metrics for a laser in a coherent application are output power, linewidth and tuning range. A linewidth of less than 500 kHz was demonstrated, along with full C-band tuning range and 1.2 mW of output power. For the polarization splitter a Polarization Extinction Ratio (PER) of more than 15 dB was shown. The measurement results of the SSC array finally shown a low loss non-uniformity of less than 1.25 dB.

With basic testing of individual components completed, the entire CRX functionality was tested using a two tone method (Figure 57). This method is described in (United States of America Patent No. US9106334B2, 2015). It involves exciting the CRX with two optical signals of differing frequency. This allows for the measurement of Common Mode Rejection Ratio (CMRR), which is an important performance metric for coherent receivers. Using this method, a CMRR at 22 GHz of 16 dB was measured for the signal and of 15 dB for the LO. Additionally, we measured phase errors of less than 5 degrees. This is sufficient for the PASSION application.

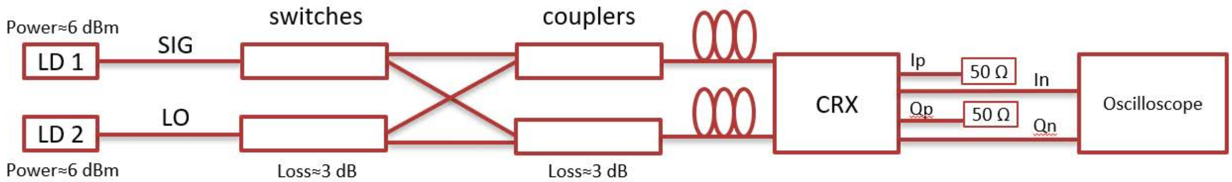
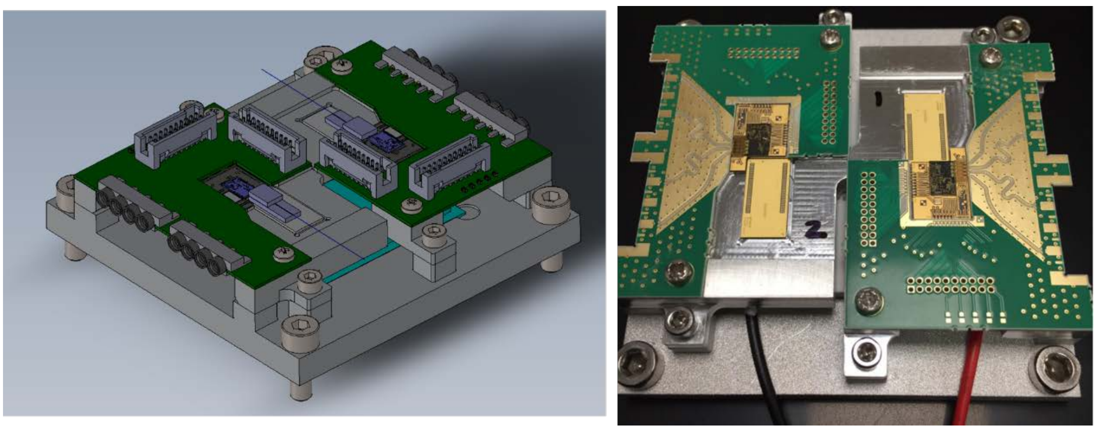


Figure 57. Experimental setup for characterizing CMRR using the two-tone method.

4.2 Coherent Receiver Integration

The CRX PIC was co-packaged with a Trans-Impedance Amplifier and TEC to create the Coherent Receiver Module (CRM). Figure 58 shows the design and realized CRM. In this module all the electrical contacts of the PIC are first wire-bonded to an aluminium-nitride tile. The traces are fanned out on the tile and then wire-bonded to a high-speed Printed Circuit Board Assembly (PCBA). The PCBA has 8 high-speed RF connectors and a single multi-contact low-speed connector. By connecting these to a testbed containing driving electronics, the entire module can be tested.



a) *b)*

Figure 58: Assembly Mechanics. a) 3D MCAD showing full assembly. b) Picture of assembled ICROSA.

To allow for testing the CRM in a systems environment, a testbed was developed. Figure 59 shows this testbed, with the CRM loaded into it. The PIC contains 75 contacts that connect to 30 DC current and voltage sources, and 8 RF cables. The other 37 contacts are grounds.

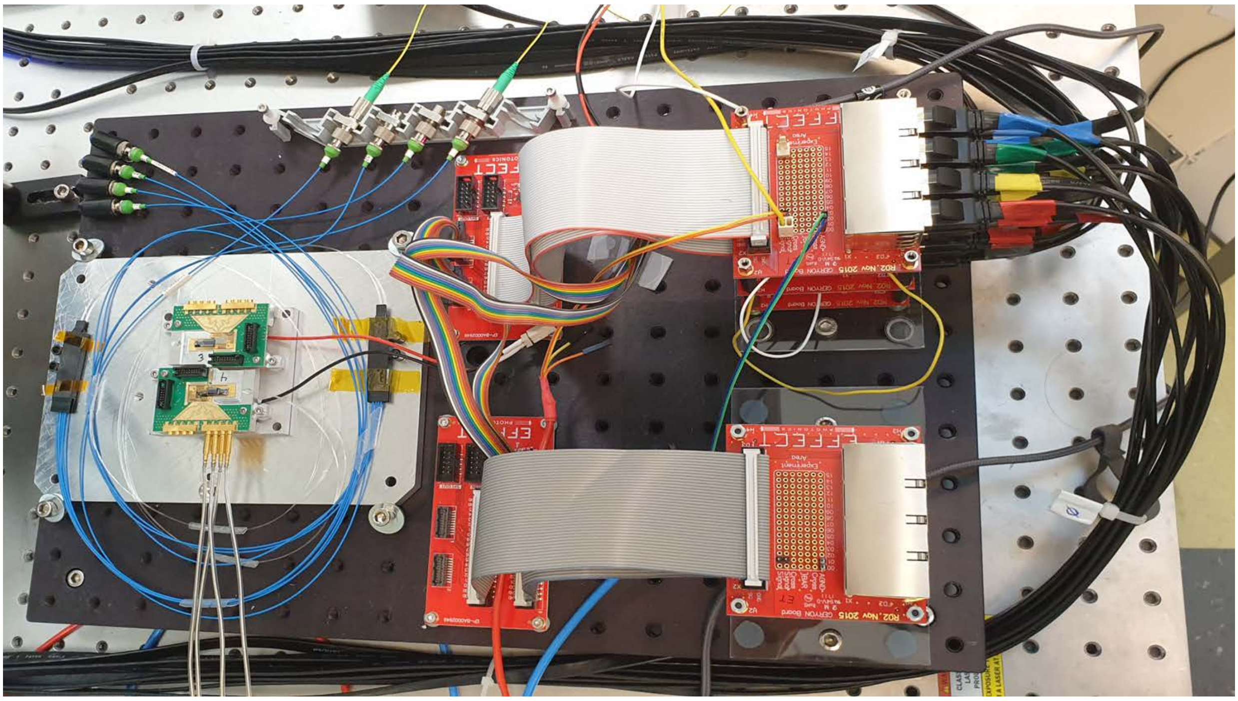


Figure 59: ICROSA testbed showing electrical and optical connections.

EFP only has limited high-speed coherent test and measurement equipment available. Because of this the plan was to rely on external partners for complete high speed (up to 30 GHz) large signal validation. Due to Covid19 related travel restrictions this turned out to be impossible. Our own testing builds confidence however that the realized CRM is able to meet the requirements necessary for functioning in the PASSION system.
The small signal equipment at EFP was able to show up to 40 GHz 3-dB bandwidth up to the RF connector of the CRM. This is more than enough to meet the requirement of 30 GHz O/E bandwidth.

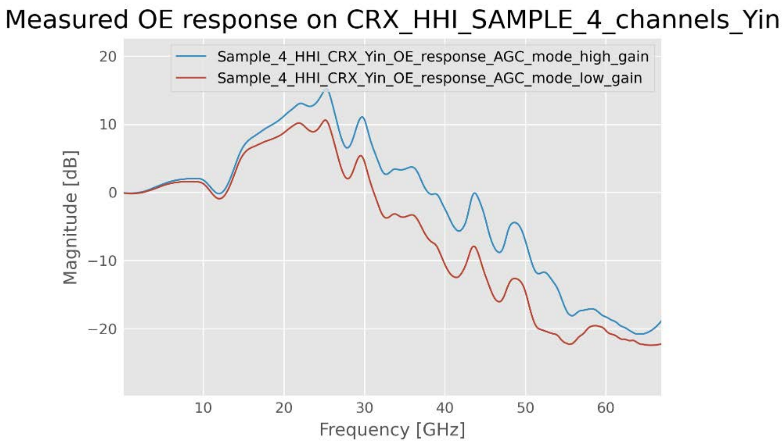
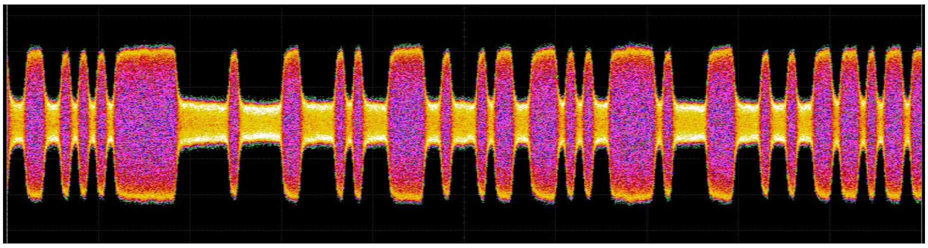


Figure 60. OE response measured on channel Yin for low and high gain and bandwidth settings

The CRM was subsequently tested in large signal operation. The test equipment was limited to On-Off Keying (OOK) at a maximum bit rate of 10 Gb/s. The results of this testing are shown in Figure 61. In Figure 61a), the detected electric field of the incoming signal is plotted. The same signal is shown in Figure 61b) after demodulation. From this it is apparent that the 1-level has quite strong noise. We believe the source of most of the noise are the SOAs on the chip. The amplification obtained out of the SOAs on the HHI platform is quite low. This causes the amplifiers to have a relatively high noise figure. Low-pass filtering cleans up the signal, resulting in an open eye (Figure 61c).



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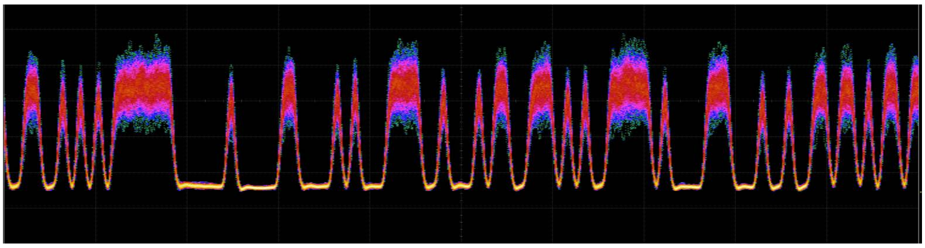

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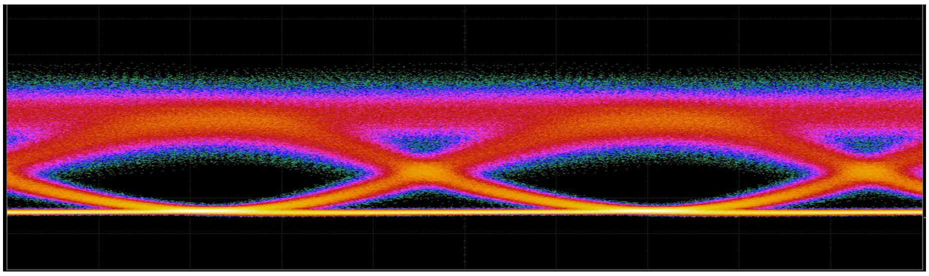


c)

Figure 61: Large signal characterization results. a) Detected E-field of 10 GB/s OOK signal, b) Demodulated and filtered with a 4th order 7.5 GHz Bessel low-pass filter to remove out of band noise associated with the TIA, c) After filtering, the eye diagram is clearly open, but a significant amount of ASE induced noise can be seen on the one level.

While due to Covid19 travel restrictions we could not conclusively demonstrate DMT coherent reception, we are confident that the receiver will be able to handle complex modulation formats. The reason for this is the demonstrated open eye for OOK modulation, combined with a verified less than 5 degree phase error in the hybrid.

5 CONCLUSIONS

In this deliverable, we have reported the proof-of-concept experiments and the validation of the technological developments constituting the fundamental building blocks of the innovative PASSION platform supporting the future sustainable high-capacity metro network. Integration activity on suitable evaluation boards is shown for several PASSION components/devices, tested in selected reference setups.

Starting from the TX module, experimentation done at POLIMI lab, supported by suitable simulations demonstrated the VCSEL-based transmission beyond 50 Gb/s per wavelength (PASSION target) over hundreds of km uncompensated SMF, also in case of dense WDM multi-channel propagation (with 25 GHz spacing as in case of the fully-equipped PASSION TX super-module). Moreover, the integration of the 40-VCSEL TX module, realized by VTT and targeting up to 2-Tb/s capacity, in a real industrial board has been described in detail, following the standard industrial process used for SMO products. The technical details of the TX module evaluation board developed by SMO are reported in the Appendix.

The experimental assessment of the components realized for the development of the switching node has been also demonstrated. Different types of components, such as the wavelength blocker, the wavelength selective switch and the multi-cast switch have been realized and tested in detail in TUE testbed. Also the impact of the SOA on the DMT-modulated PASSION signal due to the switching node crossing has been carefully analysed by POLIMI by experimentation. Moreover, the operation of the 16x16 matrix switch operating as photonic space matrix switch, realized by ETRI and based on the polymer optical waveguide of CHEM, has been described, together with its packaging and integration on a PCB board. The 16x16 switch matrix was also integrated and tested in the CTTC ADRENALINE testbed, enabling spatial switching within the developed experimental set-up at data plane level.

Finally, the coherent module designed to be compatible with a flexible infrastructure, has been assessed by EFP with its integration in an appropriate test board.

The lab-trials envisioned for the final demonstration of the capabilities of PASSION approach, performing also network-oriented experiments, are instead described in WP5 deliverable D5.4.

6 References

[Rapis20] M. Rapisarda et al.,"SOA Impact on High-Capacity DMT signals in Switching/Aggregation Node for Future MAN" in OSA Proceedings Advanced Photonics Congress 2020, 13 – 16 July 2020 OSA Virtual Event

7 Acronyms

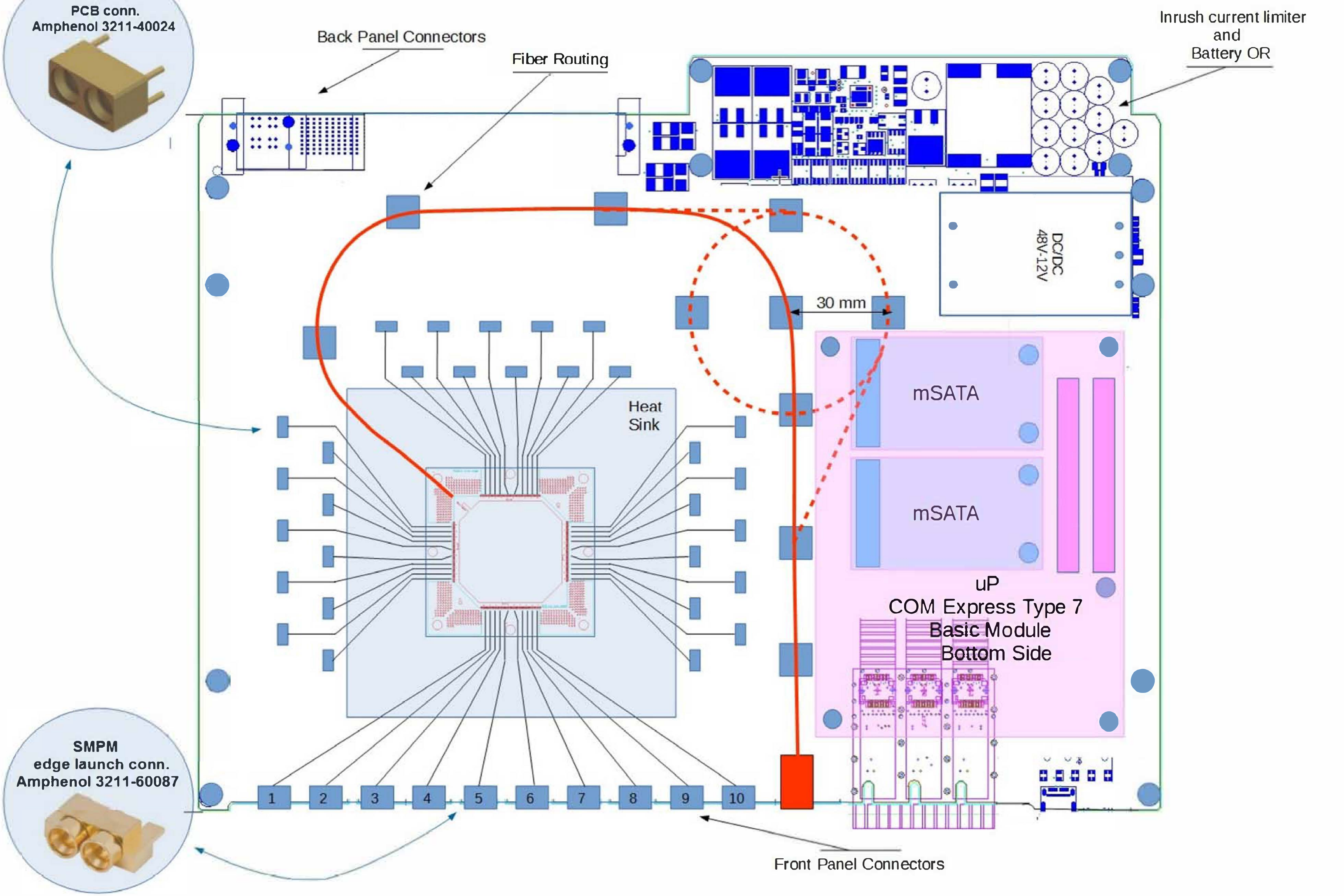
AWG	Arrayed Waveguide Grating
BER	Bit Error Rate
BL	Bit Loading
CMRR	Common Mode Rejection Ratio
CP	Cyclic Prefix
CPU	Central Processing Unit
CRM	Coherent Receiver Module
CRX	Coherent Receiver
DAC	Digital-to-Analog Converter
DM	Directly-Modulated
DMT	Discrete Multi Tone
DSB	Dual. Side Band
EDFA	Erbium Doped Fiber Amplifier
FCB	Flip Chip Bonding
FEC	Forward Error Correction
HD	Hard Decision
I/Q	In-phase/Quadrature
LGA	Land Grid Array package or Interposer
LO	Local Oscillator
MAN	Metropolitan Area Network
MCF	Multi Core Fiber
MCS	Multi Cast Switch
MM	Multi Mode
MMI	Multi-Mode Interferometer
MZI	Mach-Zehnder Interferometer
NL	Non Linear
OSNR	Optical Signal-to-Noise Ratio
PAM	Pulse Amplitude Modulation
PC	Personal Computer
PCB	Printed Circuit Board
PCBA	Printed Circuit Board Assembly
PDM	Polarization Division Multiplexing
PIC	Photonics Integrated Chip
PL	Power Loading
RX	Receiver
S-BVT	Sliceable Bandwidth/Bitrate Variable Transceiver

SGM	Self-Gain Modulation
SiPh	Silicon Photonics
SM	Single Mode
SOA	Semiconductor Optical Amplifier
SOI	Silicon-On-Insulator
SOP	State-of-Polarization
SPM	Self Phase Modulation
SSB	Single. Side Band
SSMF	Standard Single-Mode Fiber
TEC	Thermo Electric Cooler
TIR	Total Internal Reflection
TX	Transmitter
VCSEL	Vertical Cavity Surface Emitting Laser
VE	Volterra Equalization
WBL	Wavelength BLocker
WDM	Wavelength Division Multiplexing
WSS	Wavelength Selective Switch
XPM	Cross Phase Modulation

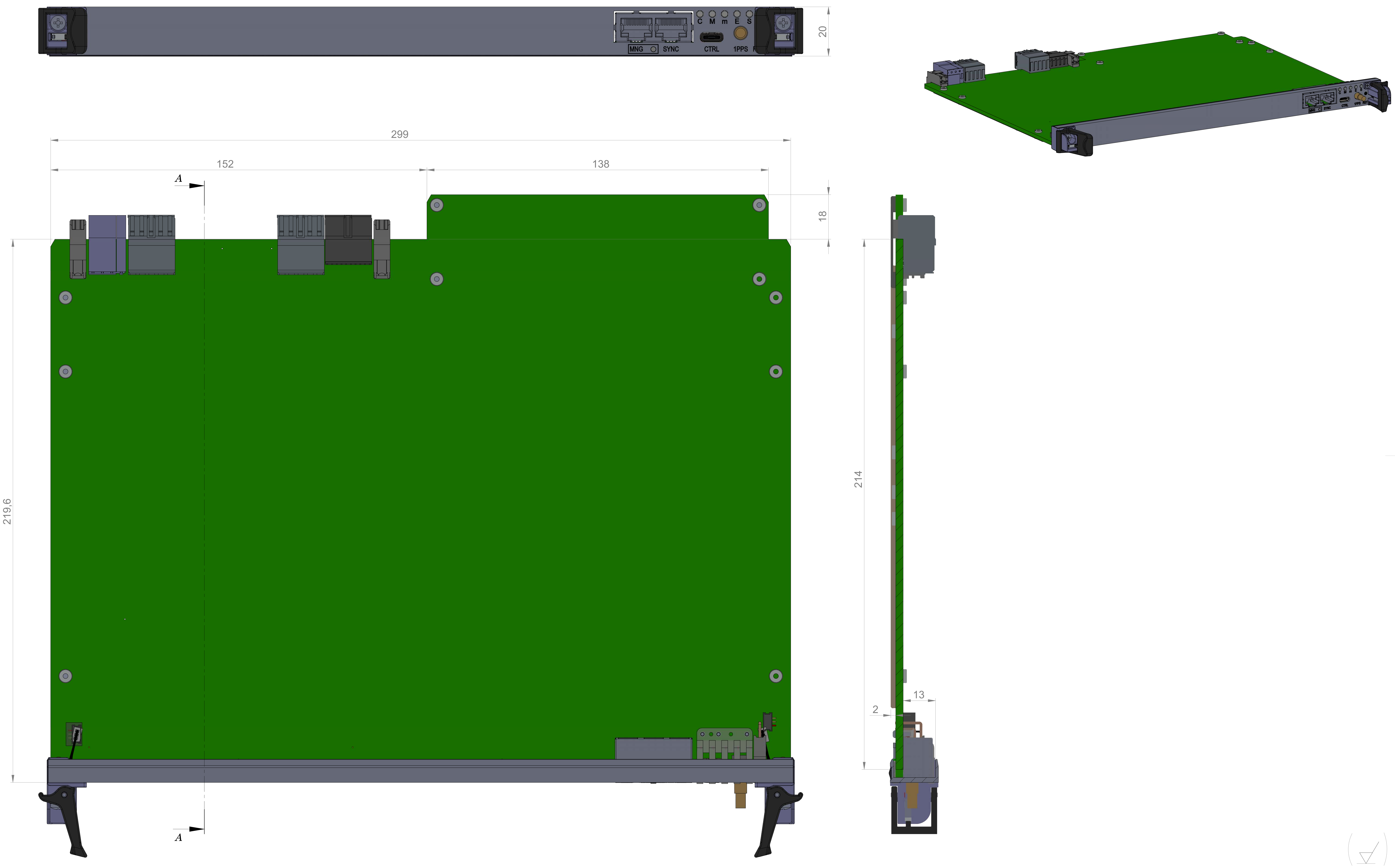
8 APPENDIX

8.1 SMO EVALUATION BOARD DESIGN AND MANUFACTURING

8.1.1 High level Board Architecture (pag. 1)



8.1.2 Mechanical Drawing (pagg. 2-5)



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WEIGHT(g): -

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VERSION:

	NAME	DATE
DRAWN	R.ZANCHI	28/02/2019
APPV'D		

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siae microelettronica group

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SHEET: 1 of 1

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MODEL: 100GBASIC_MAX_SSY | LAST SAVED: GIOVEDÌ 28 FEBBRAIO 2019 11:53:00 | BY: ZANCHR

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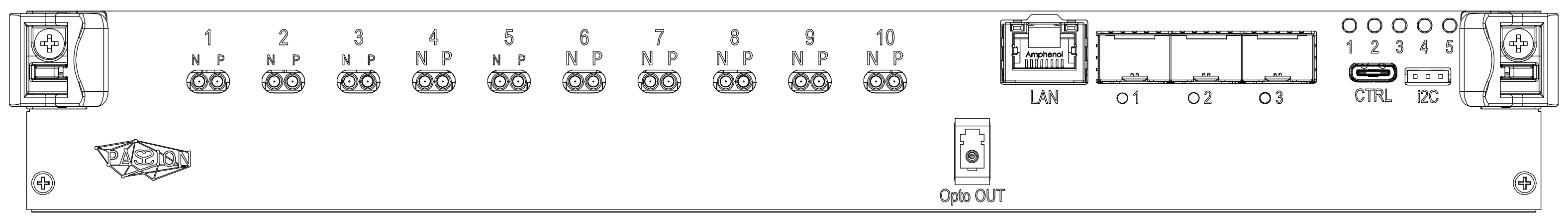

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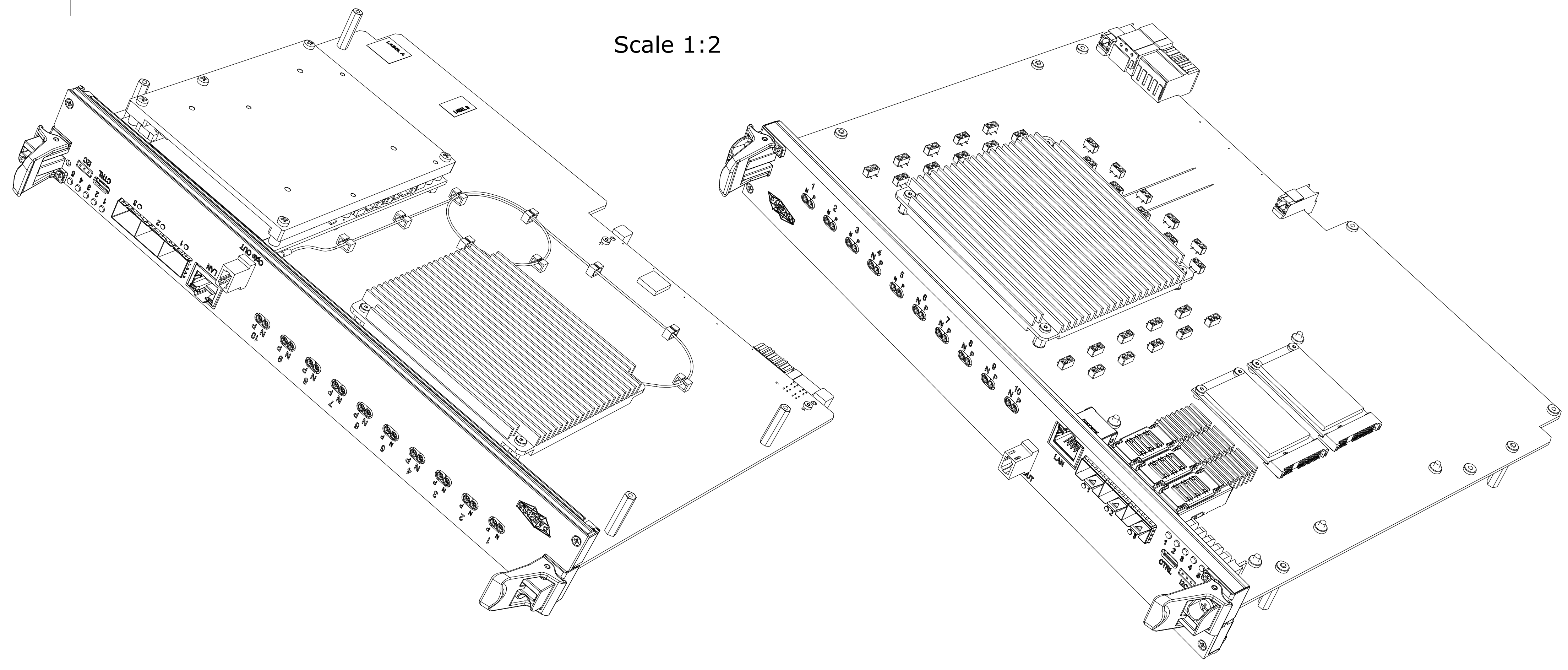

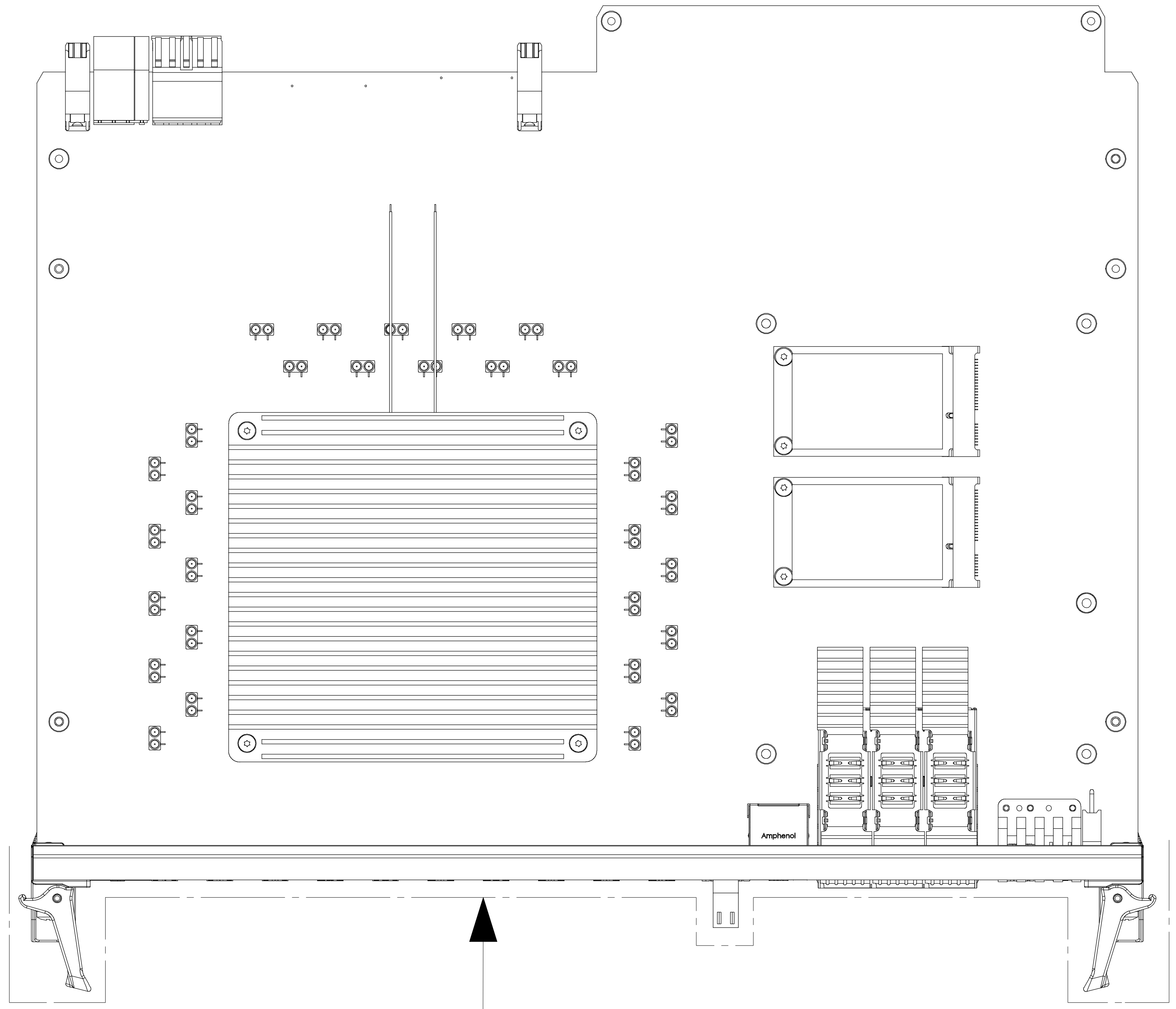

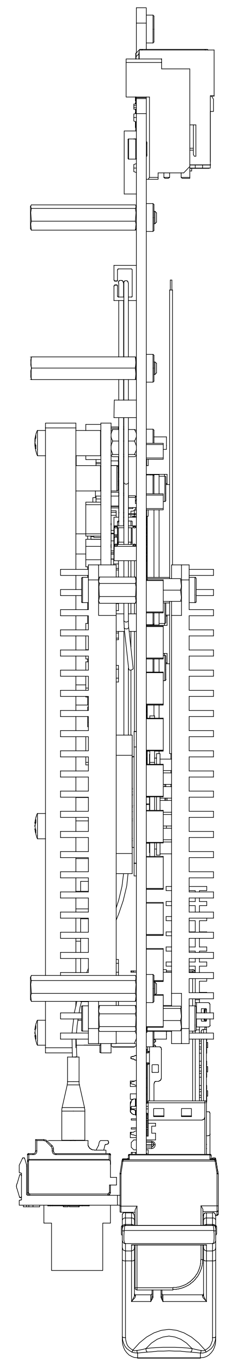

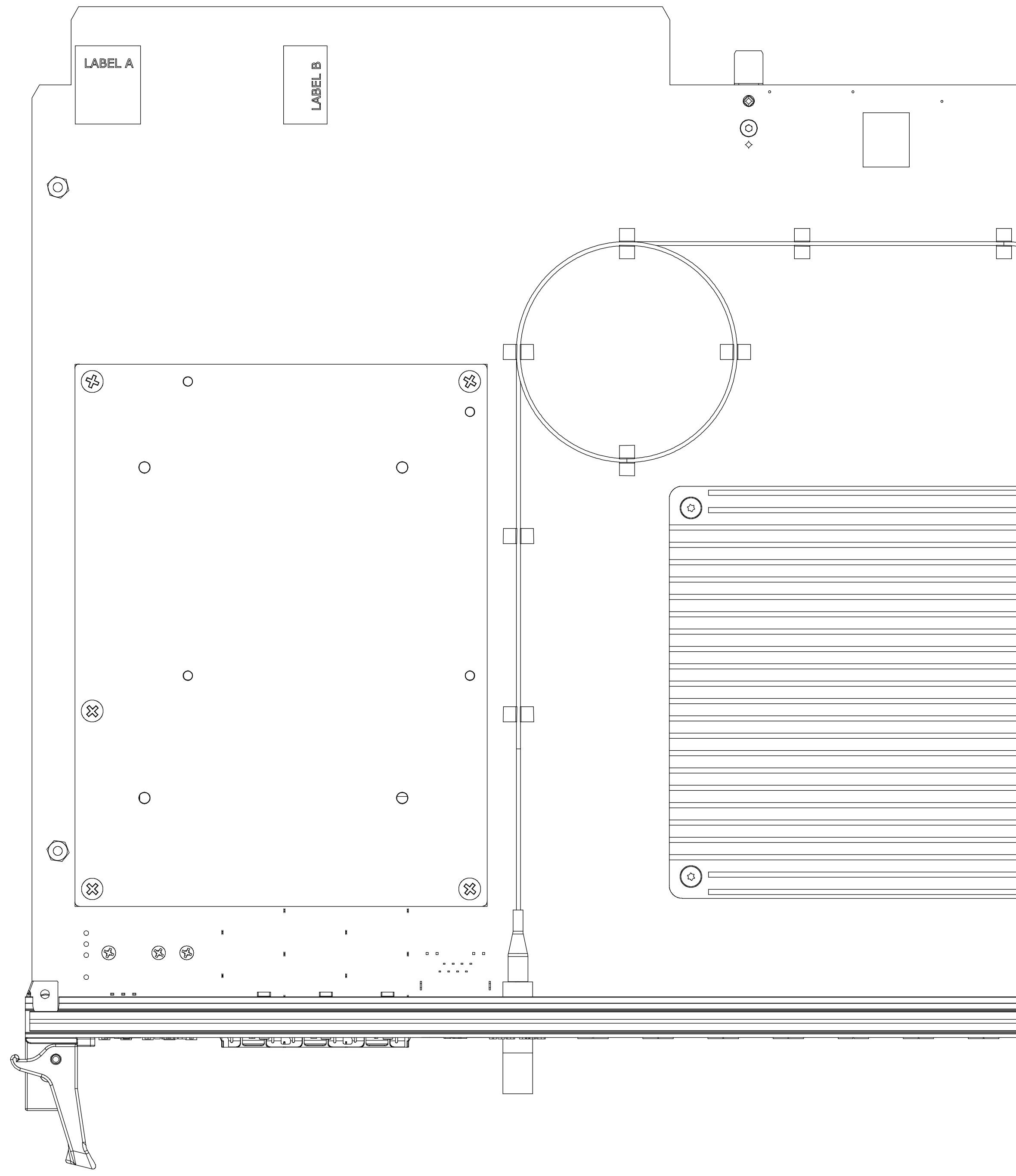

ON THE FRONT VIEW, GRADE 2 SURFACES

NOTES:

1. SURFACES MUST BE COMPLY WITH STANDARD IPC-A-610DC TELECOM ADDENDUM . IF NOT OTHERWISE INDICATED, SURFACES ARE CONSIDERED GRADE 3 .
2. TIGHTENING TORQUE ACCORDING TO PL.00102 IF NOT OTHERWISE SPECIFIED .
3. FILL IDENTIFICATION LABEL A and B AS PER NG.00503 ETI 1503 OR ETI 1504 and APPLY ACCORDING TO DRAWING .
4. VISIBLE TEXT AND SYMBOLS ARE ONLY INDICATIVE .
5. APPLY A DROP OF THREAD LOCKER N00182 .
6. THERE ARE PARTS THAT NOT ARE IN BOM MATERIALS SIGNED "TBD" .
7. LOCATIONS OF FIBER HOLDERS AND OPTIC FIBER CAN BE ADJUSTED BY OEM TO OPTIMIZE THE ROUTING .

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APPV'D	ZANCHR			

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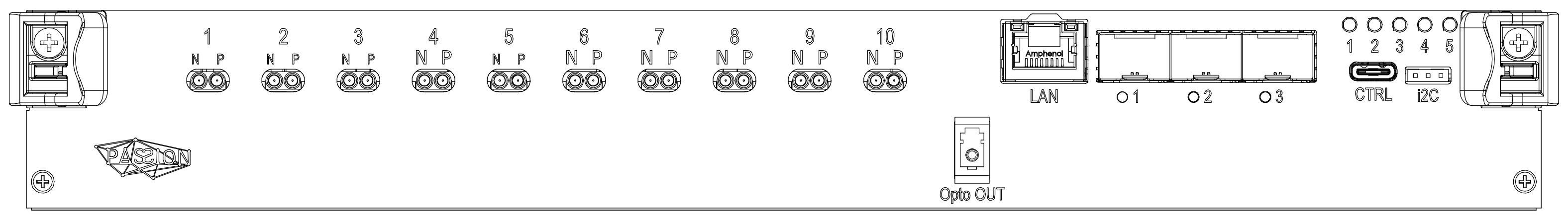
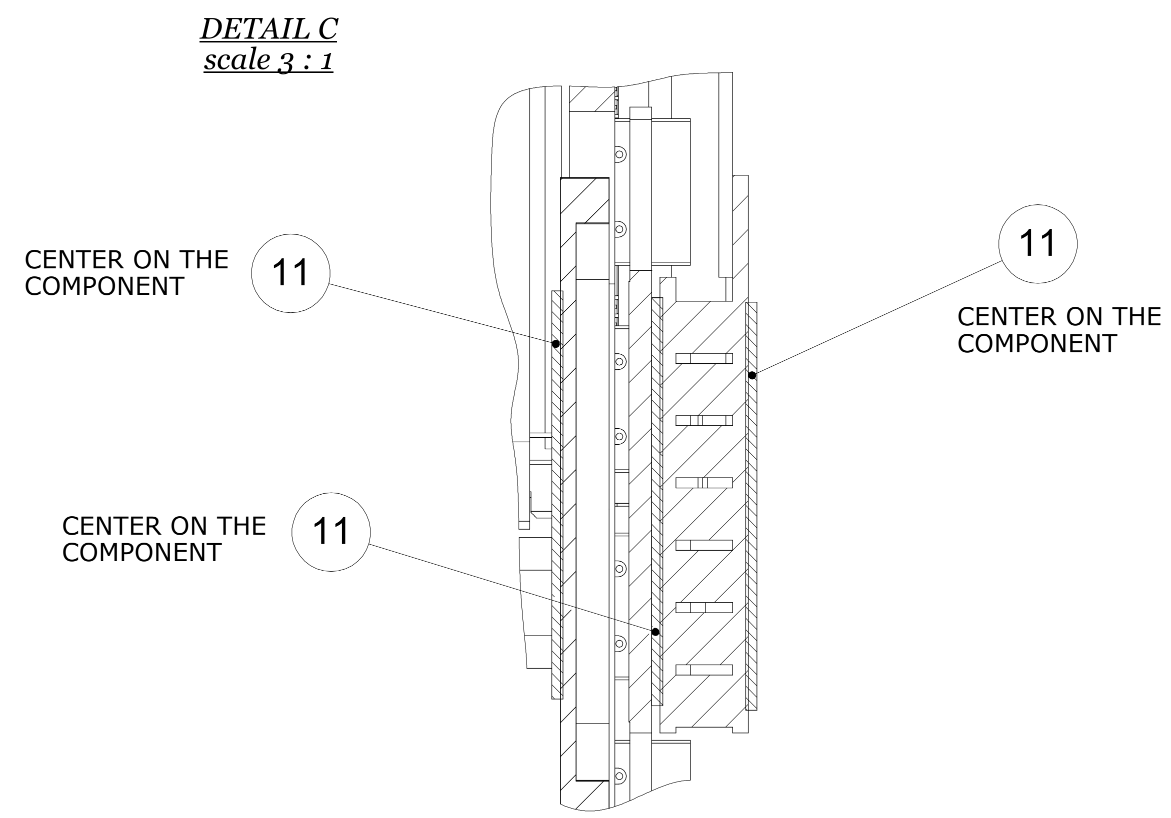
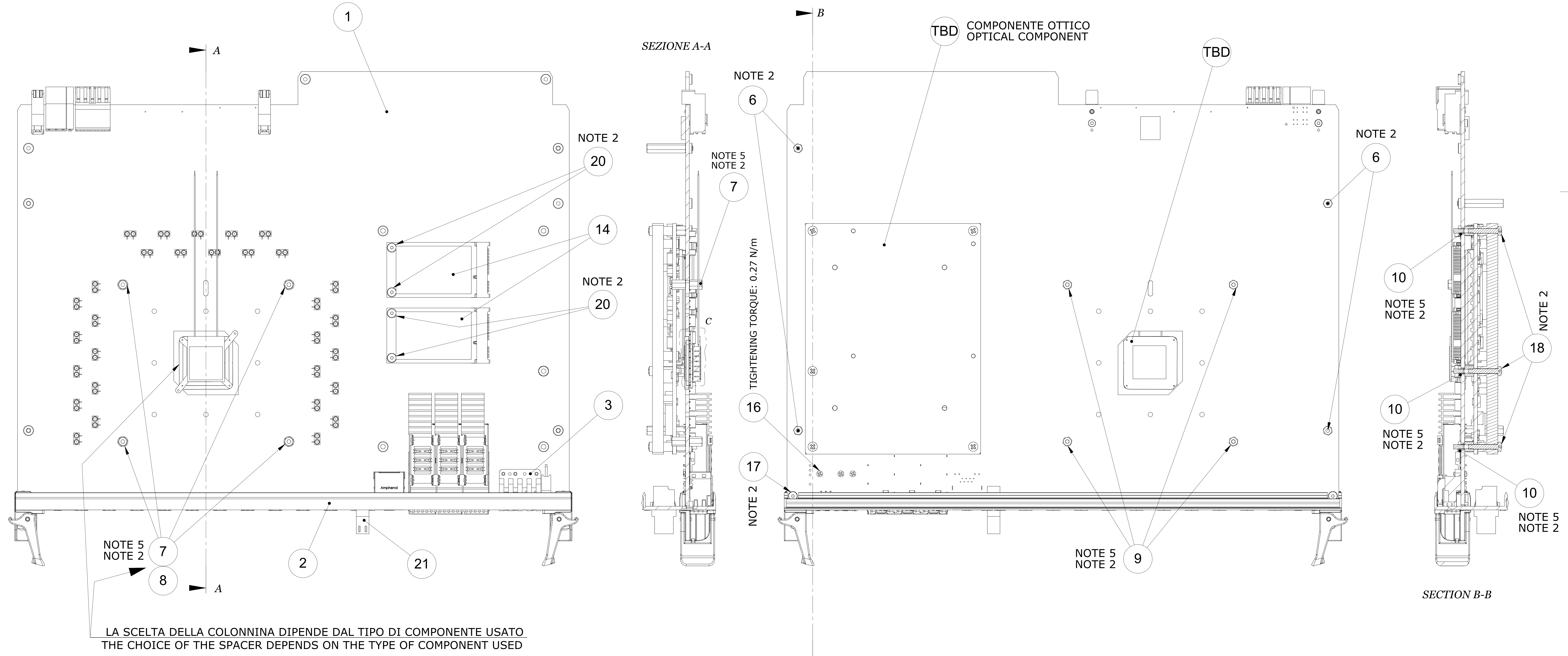
FASE 1
PHASE 1







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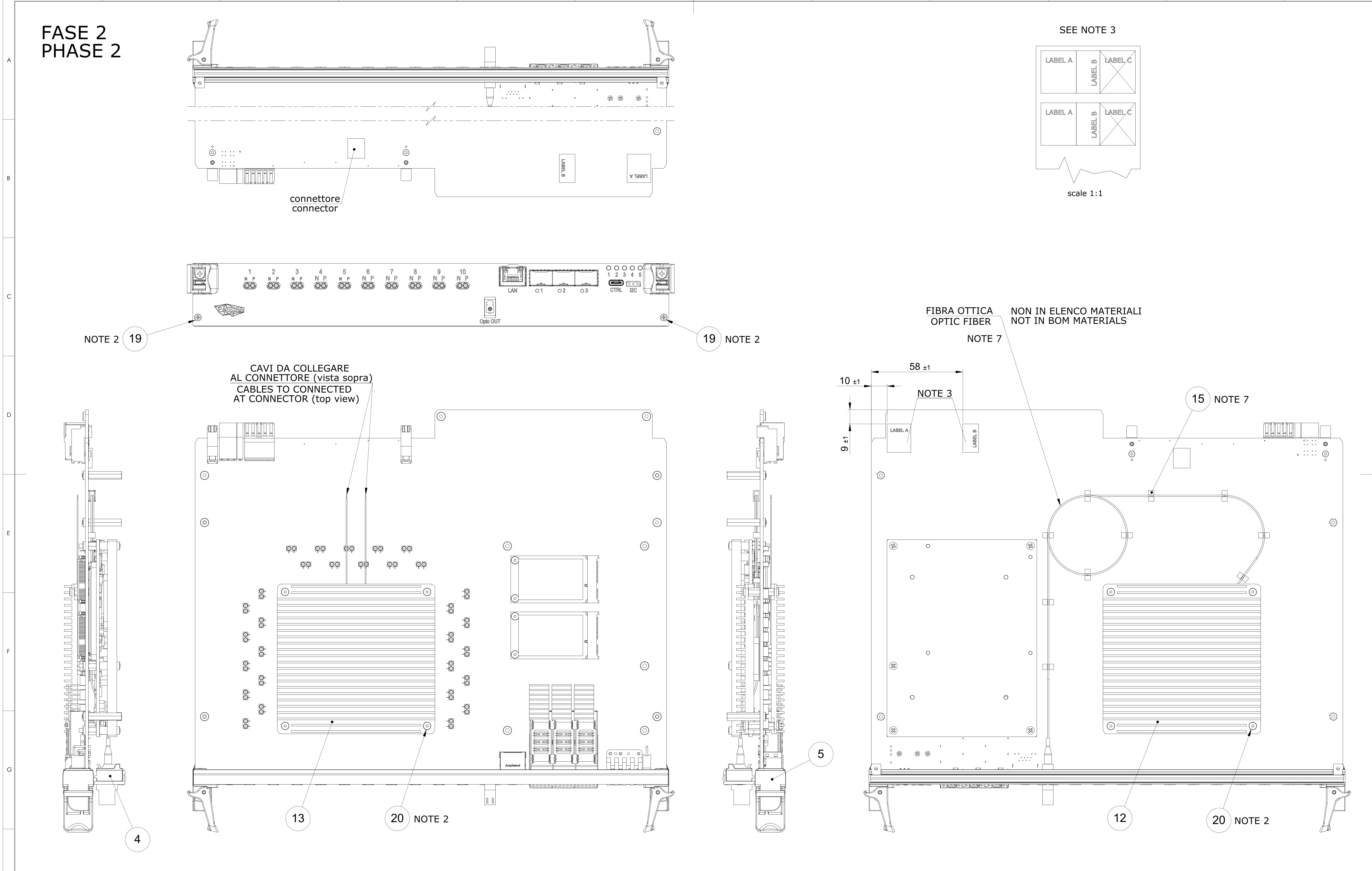

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SCALE: 1:1.5
SHEET: 3 of 3

8.1.3 Board Schematics (pagg. 6-56)

PASSION 2020

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NET COLOR LEGEND

TNV2+	——
TNV2	——
TNV2-	——
VCC	——
GND	——
GNDM	——
50 ohm	——
100 ohm DIFF	——
100 ohm DIFF HF	——
SELV	——

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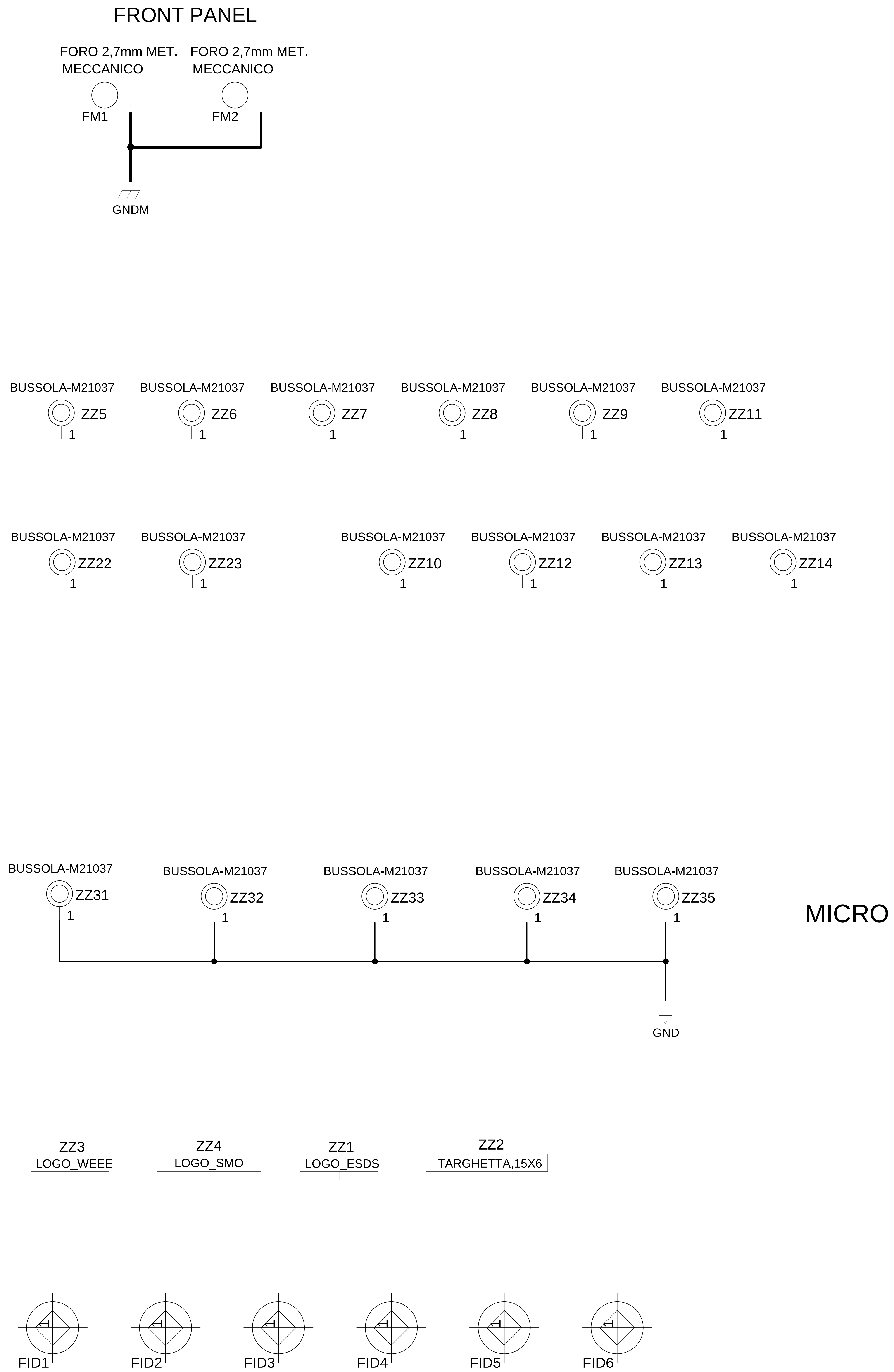

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ADJ-Current Range: Min 0,31A Max 0,75A

R ILIM = 330 Ohm > 0.75 Amp Limit

VSNS switch when VC3.3V is lower than 3.15V (due to R divider)

VSNS is the Hysteresis between 3.3VA-VB to VC3.3V

if it is needed more current , take in consideration the tps2113

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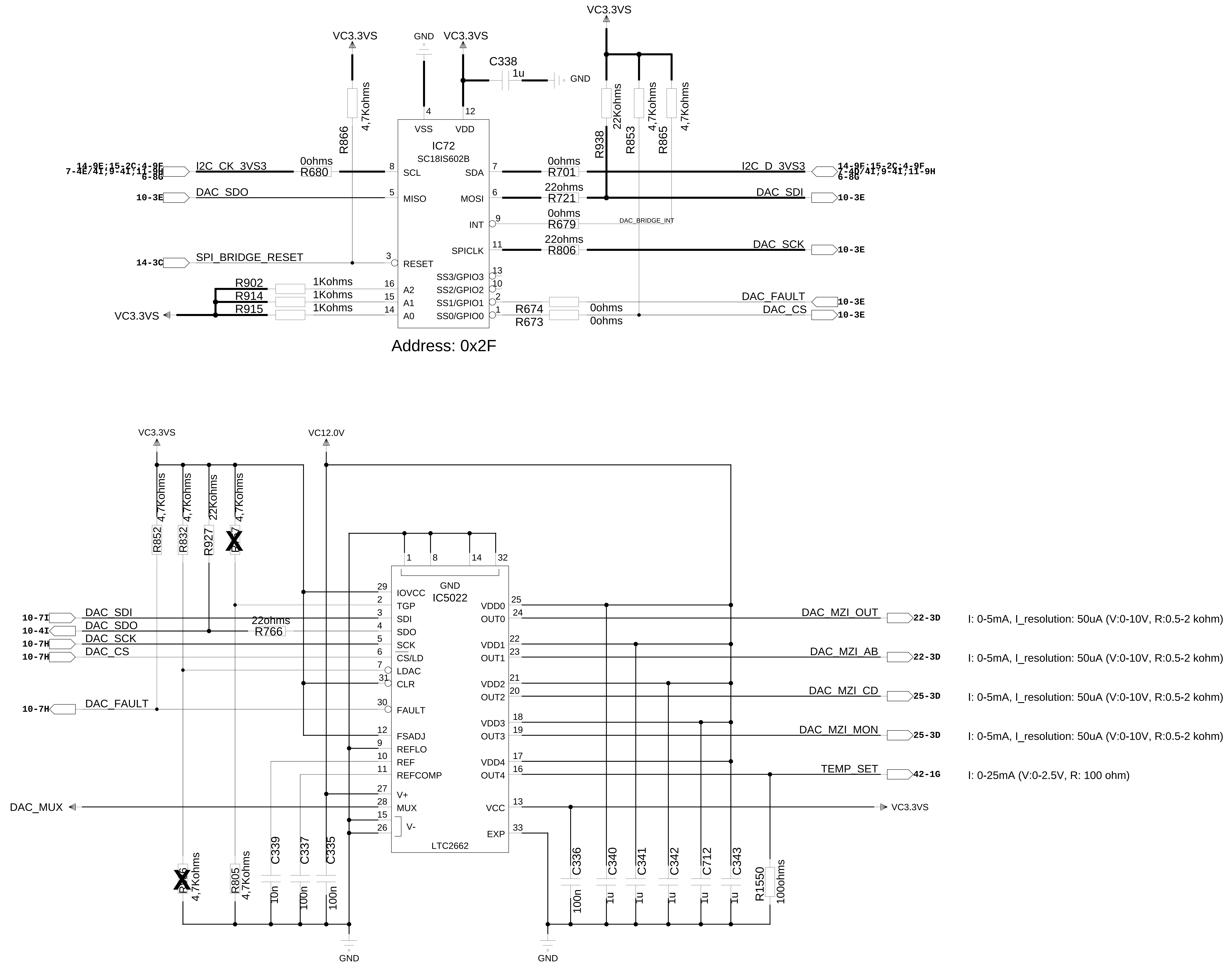

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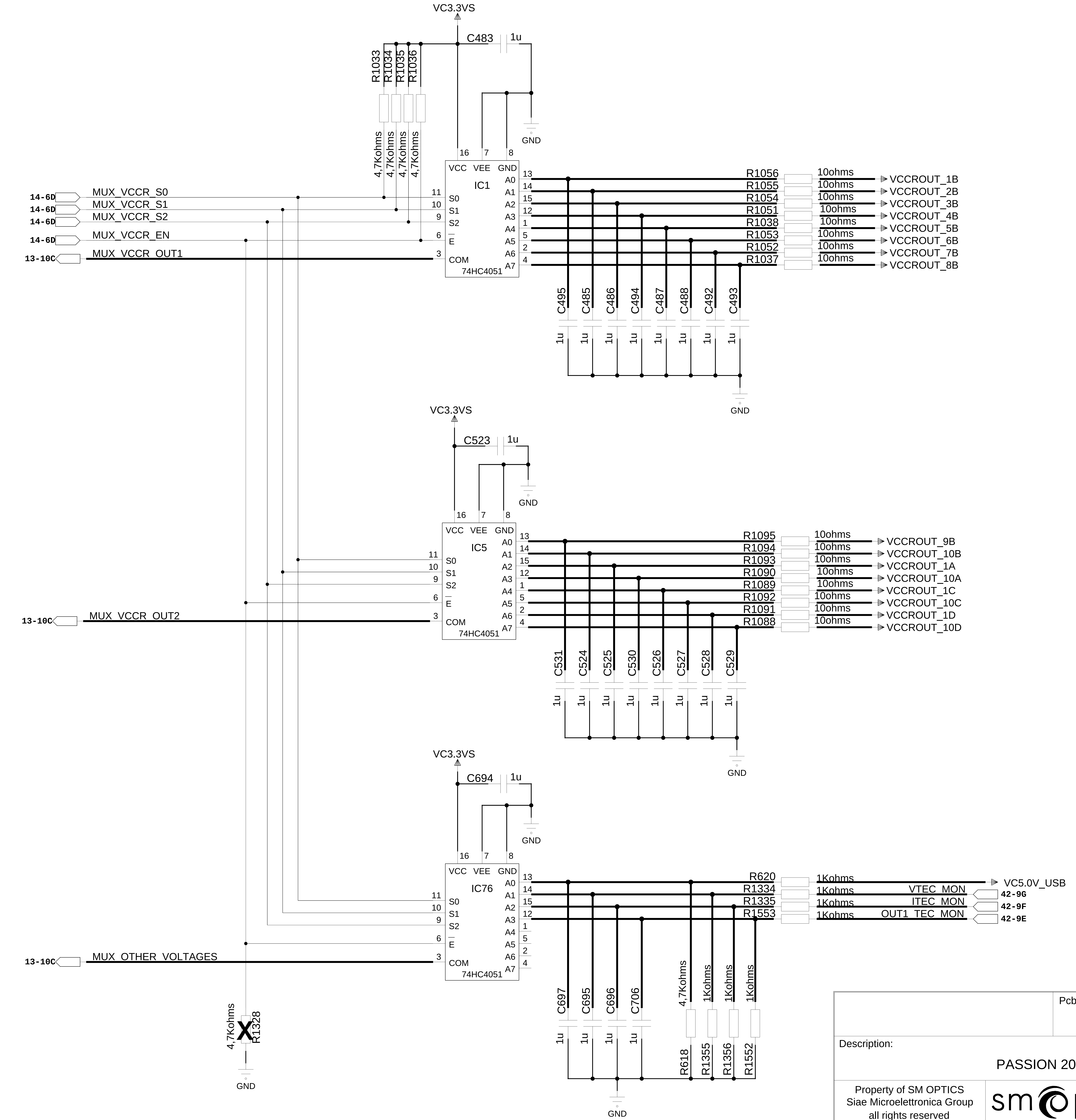

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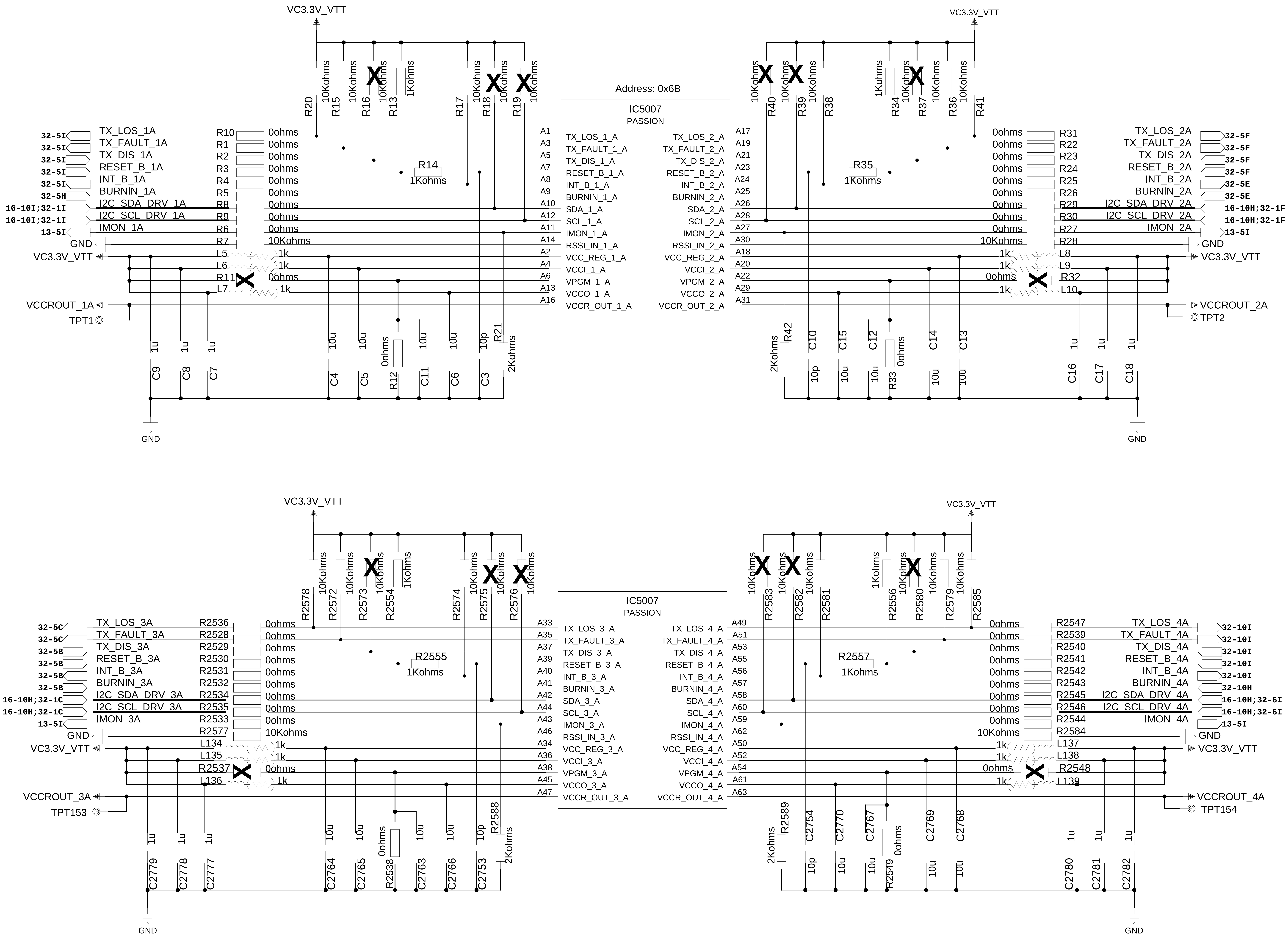
UT_modA3_SMO rev.001 25-02-16



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Description: PASSION 2020

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Date: 04/04/2019
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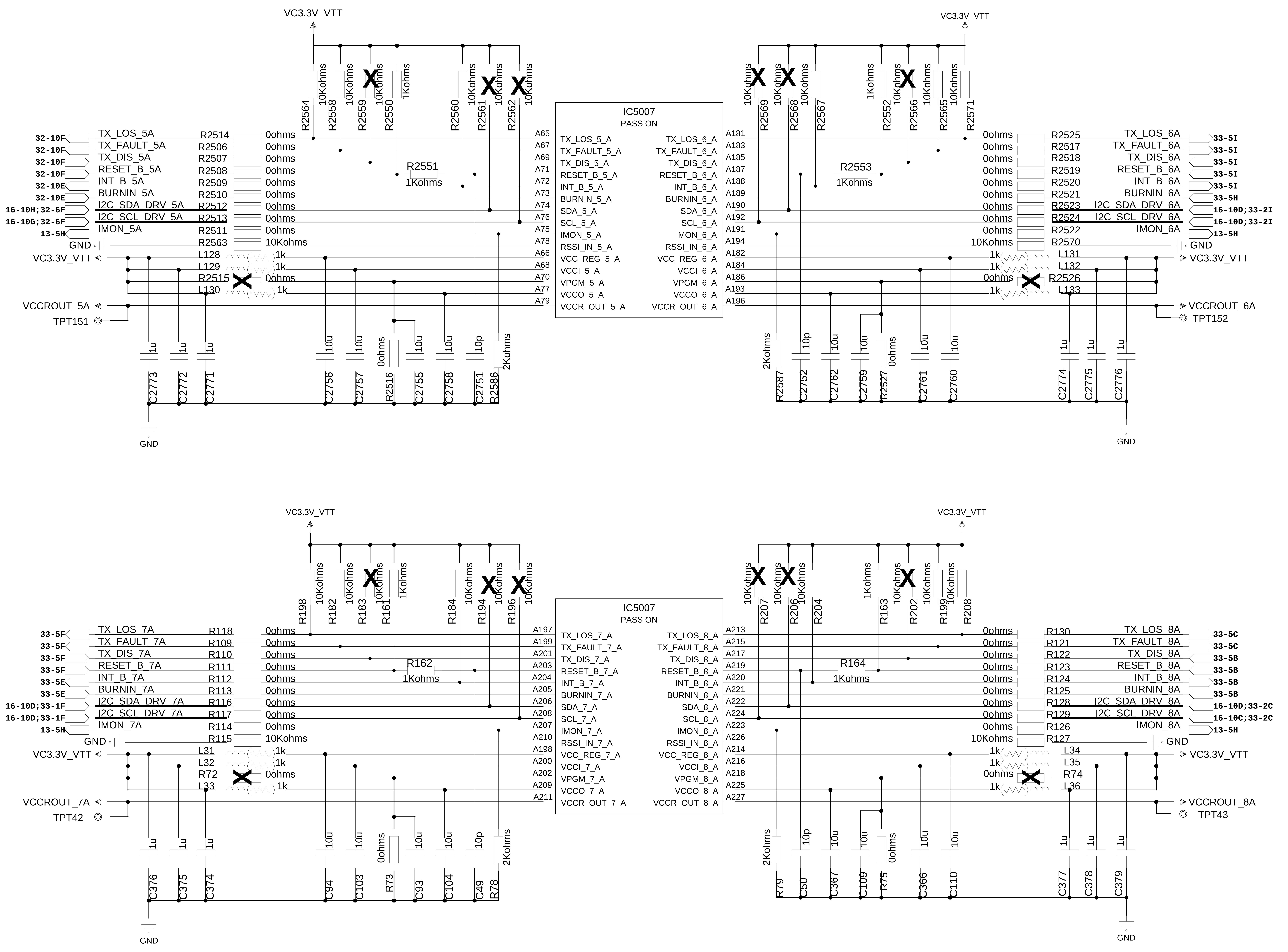

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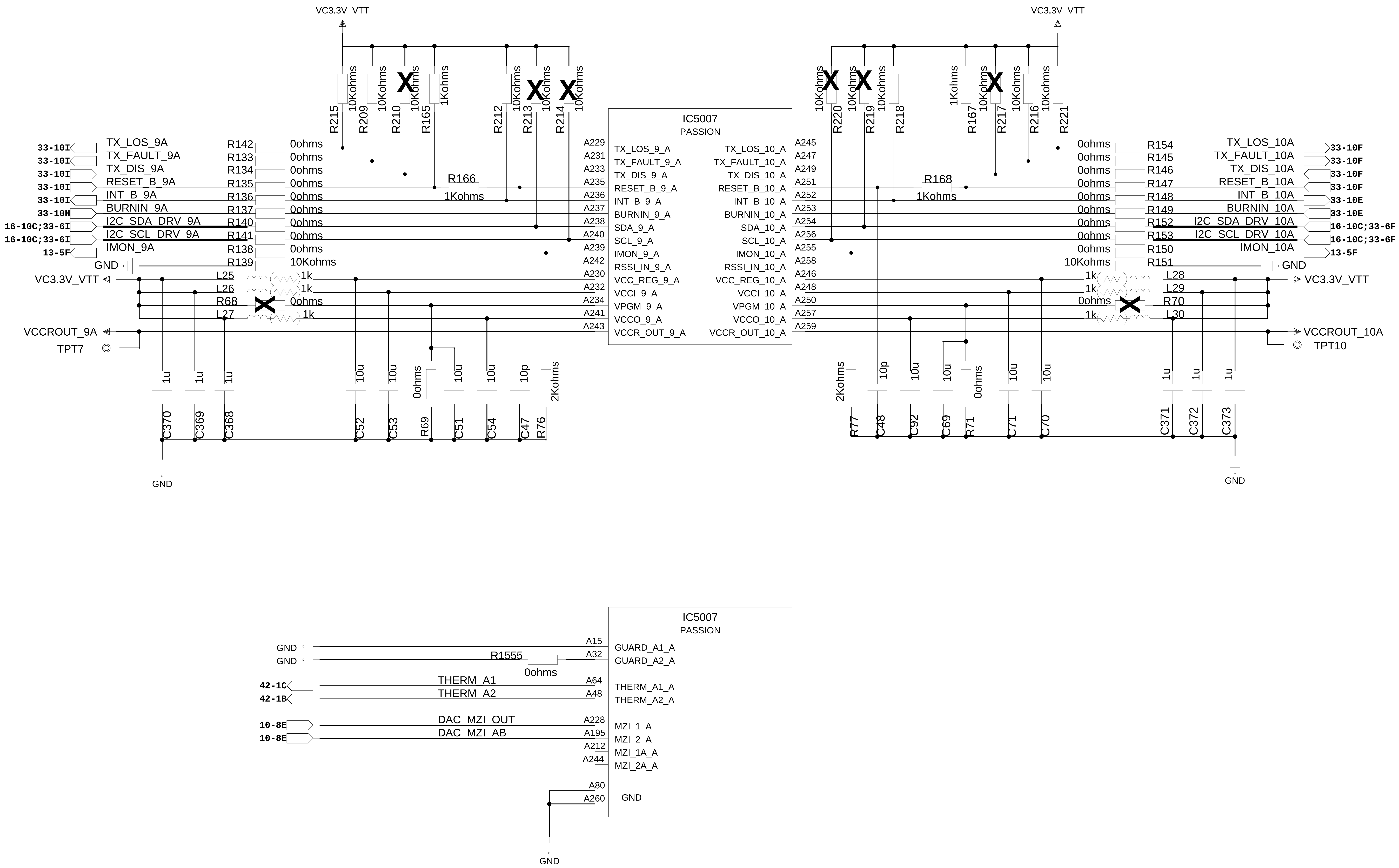

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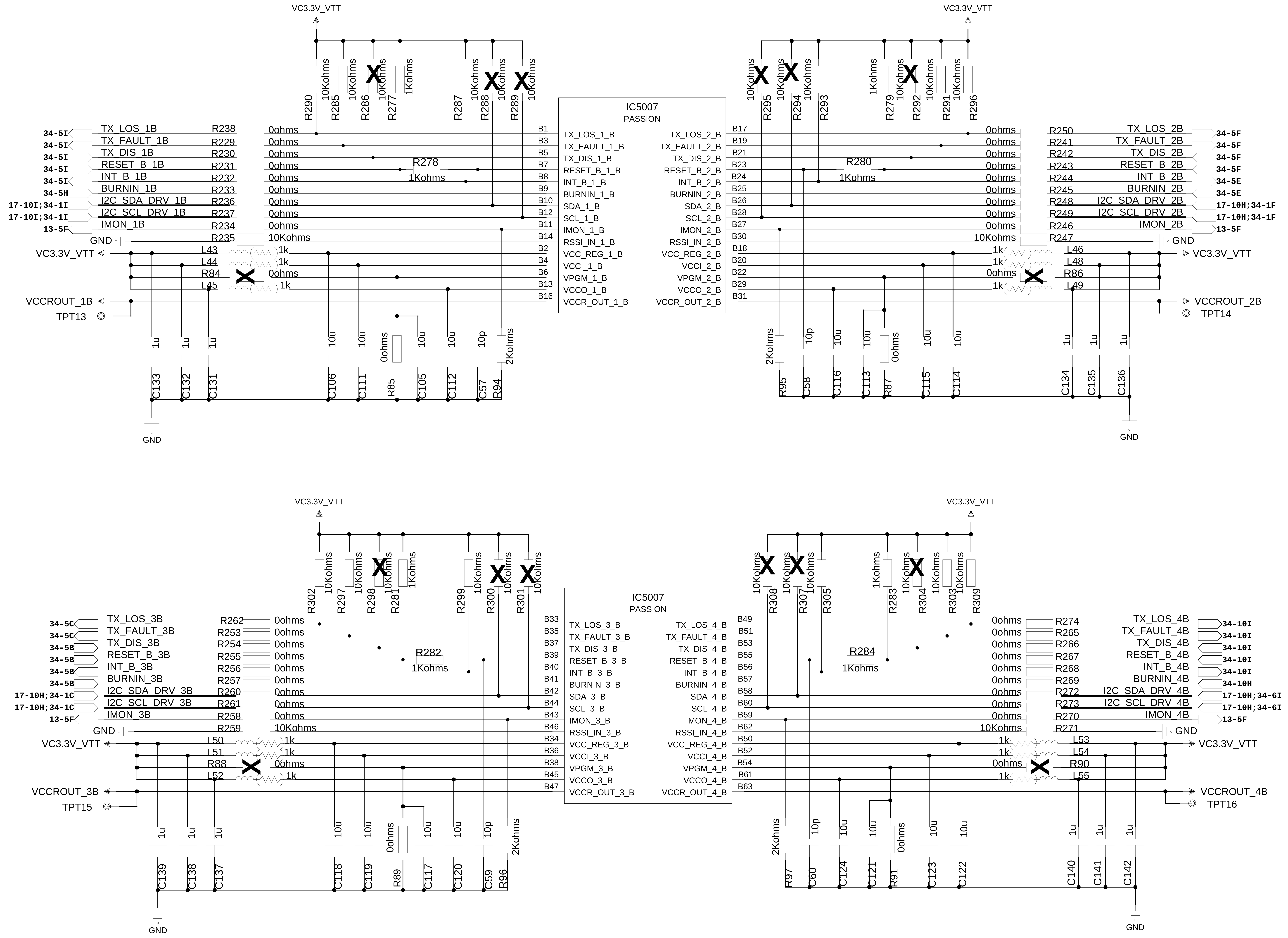

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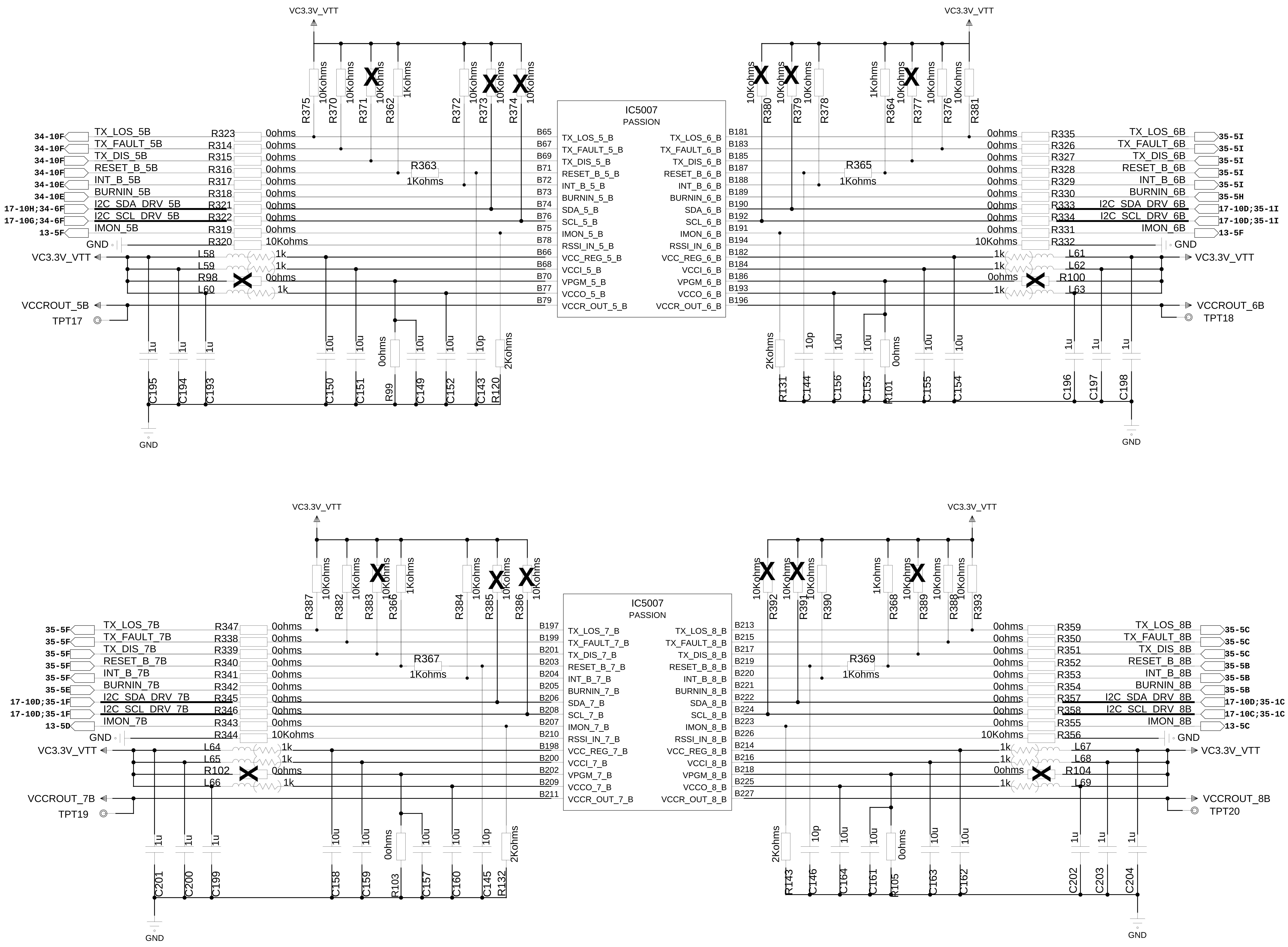

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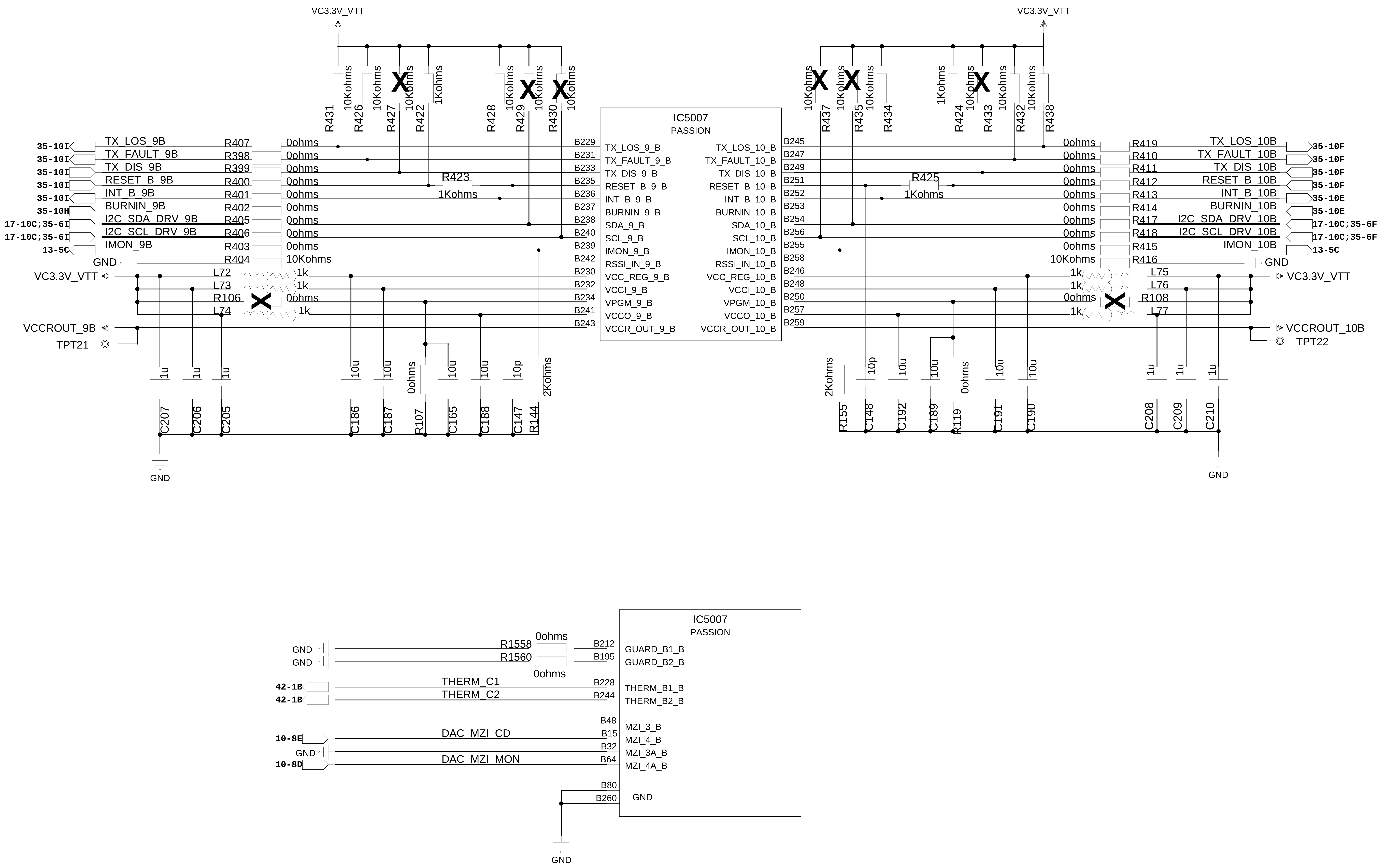

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Description: PASSION 2020	Issued by: MALASI	Approved by: SEVERM	Date: 04/04/2019
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Description: PASSION 2020		Issued by: MALASI	Approved by: SEVERM	Date: 04/04/2019	Page: 26 / 51
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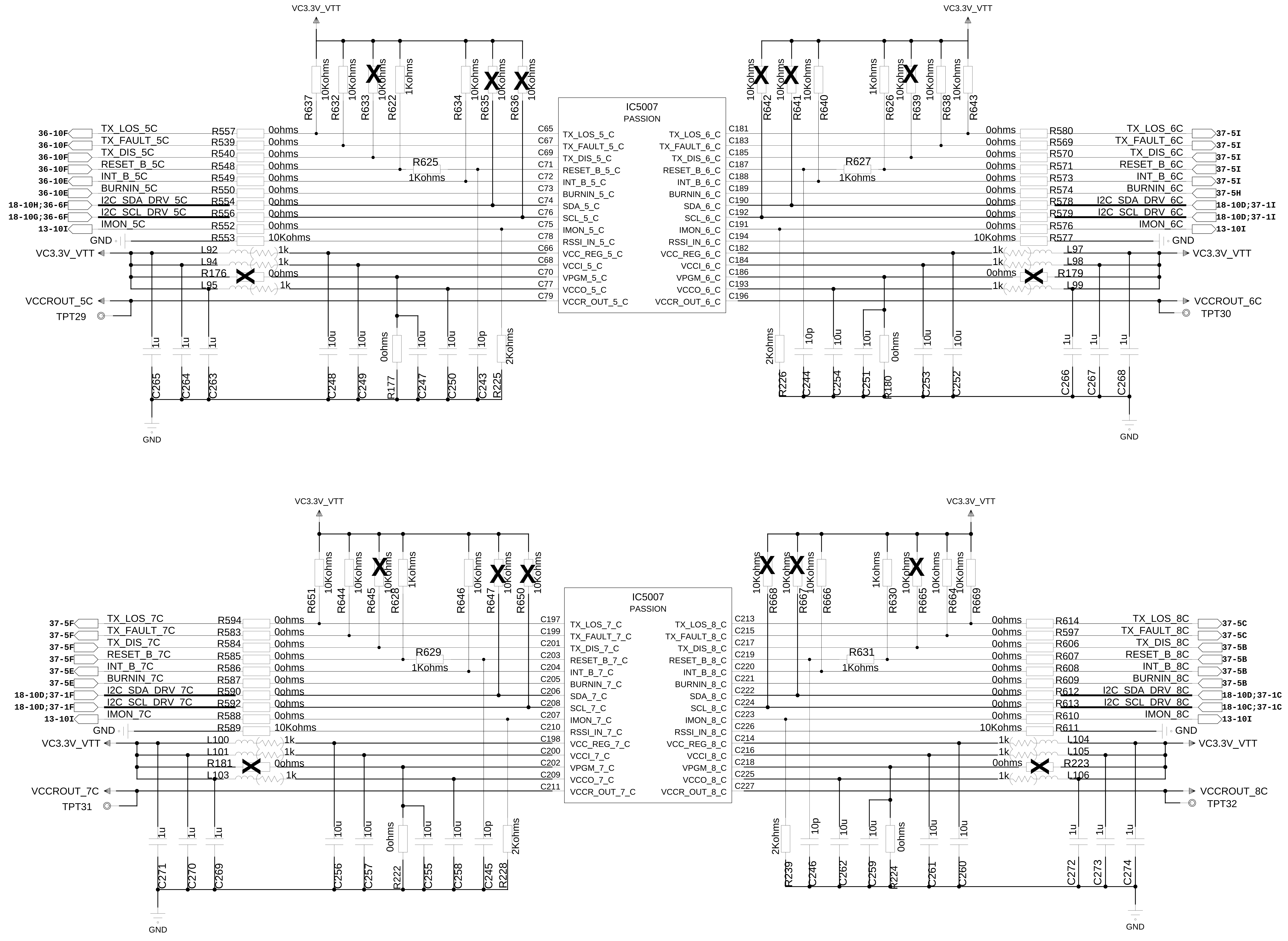

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A B C D E F

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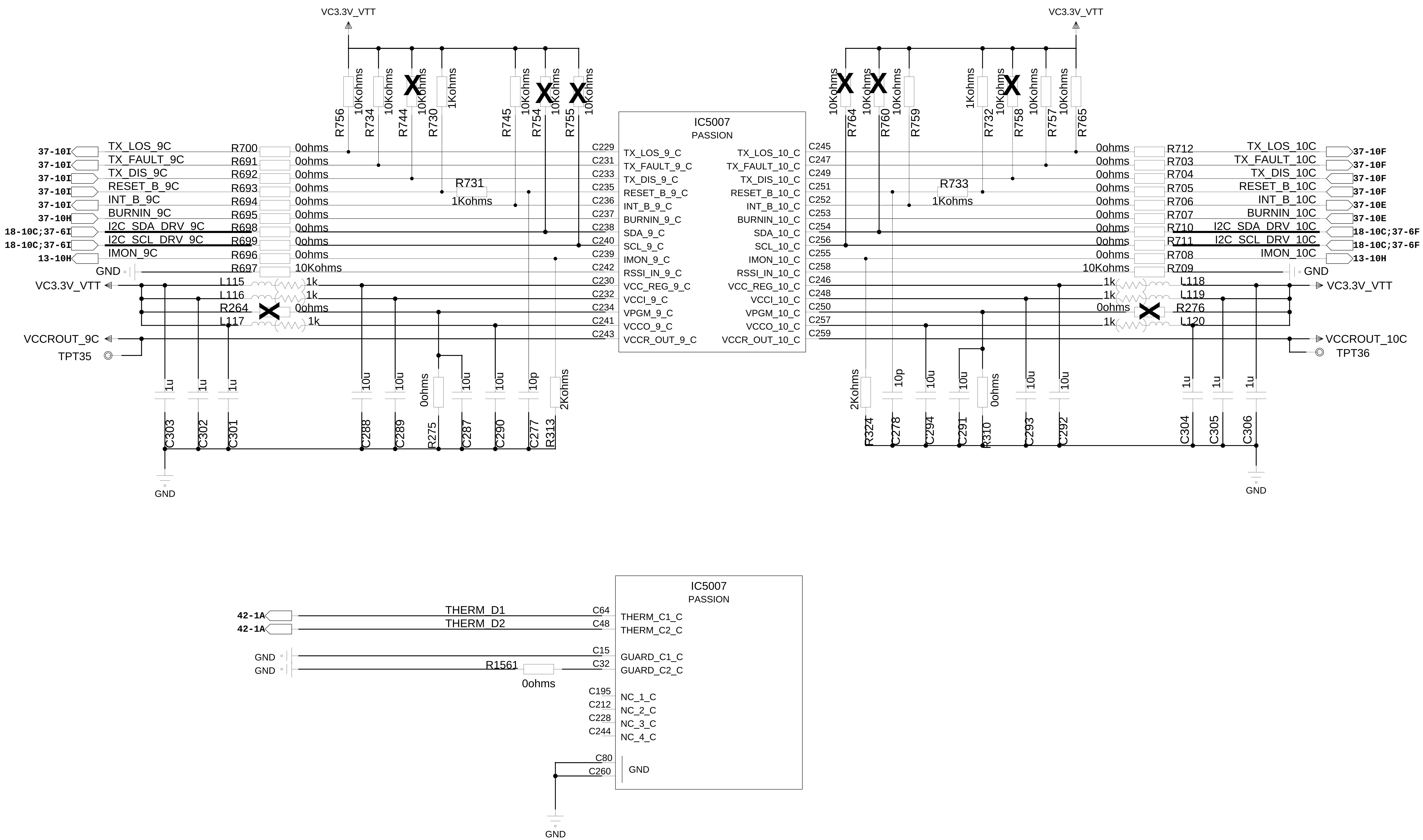

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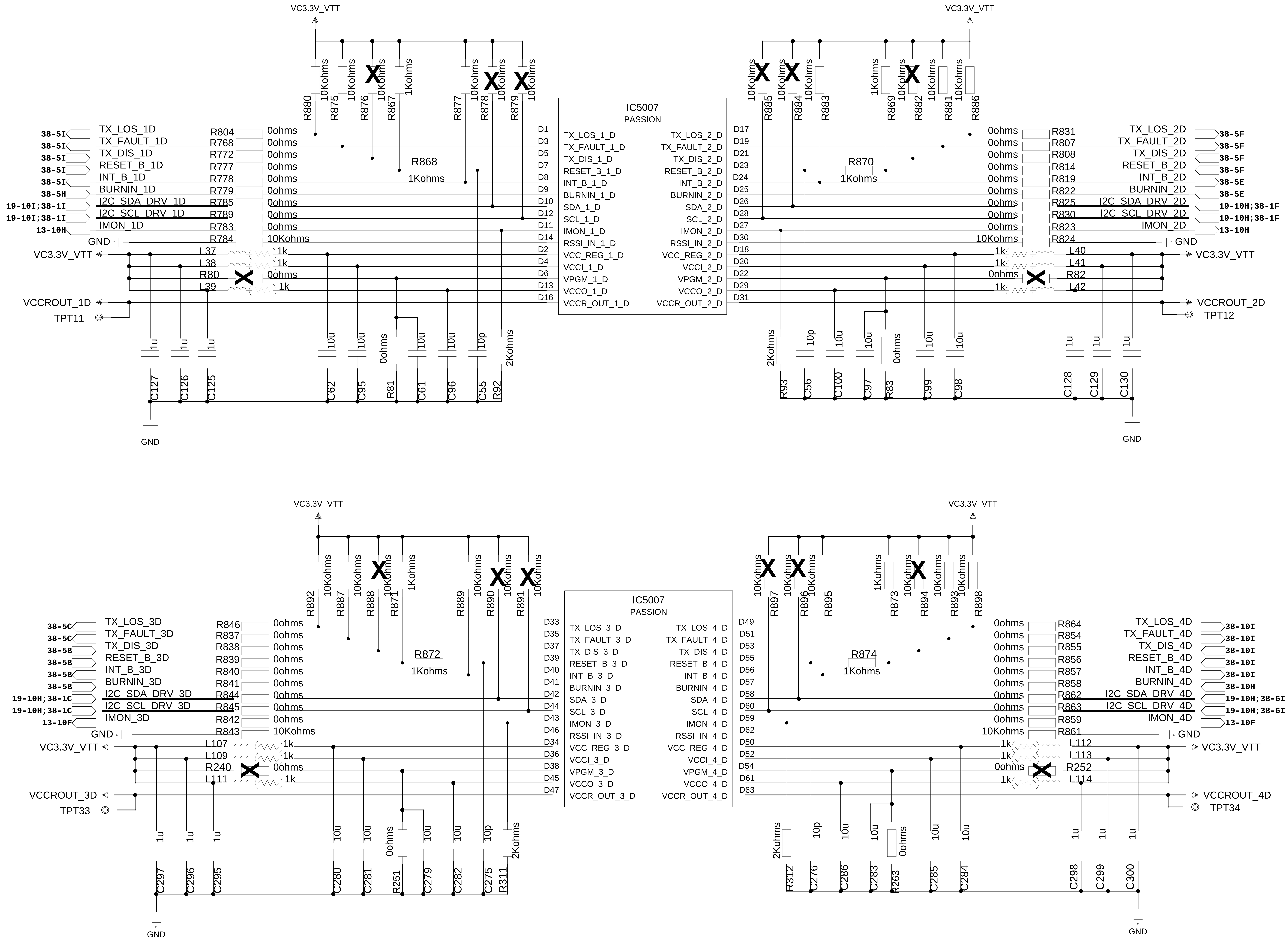

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Description: PASSION 2020

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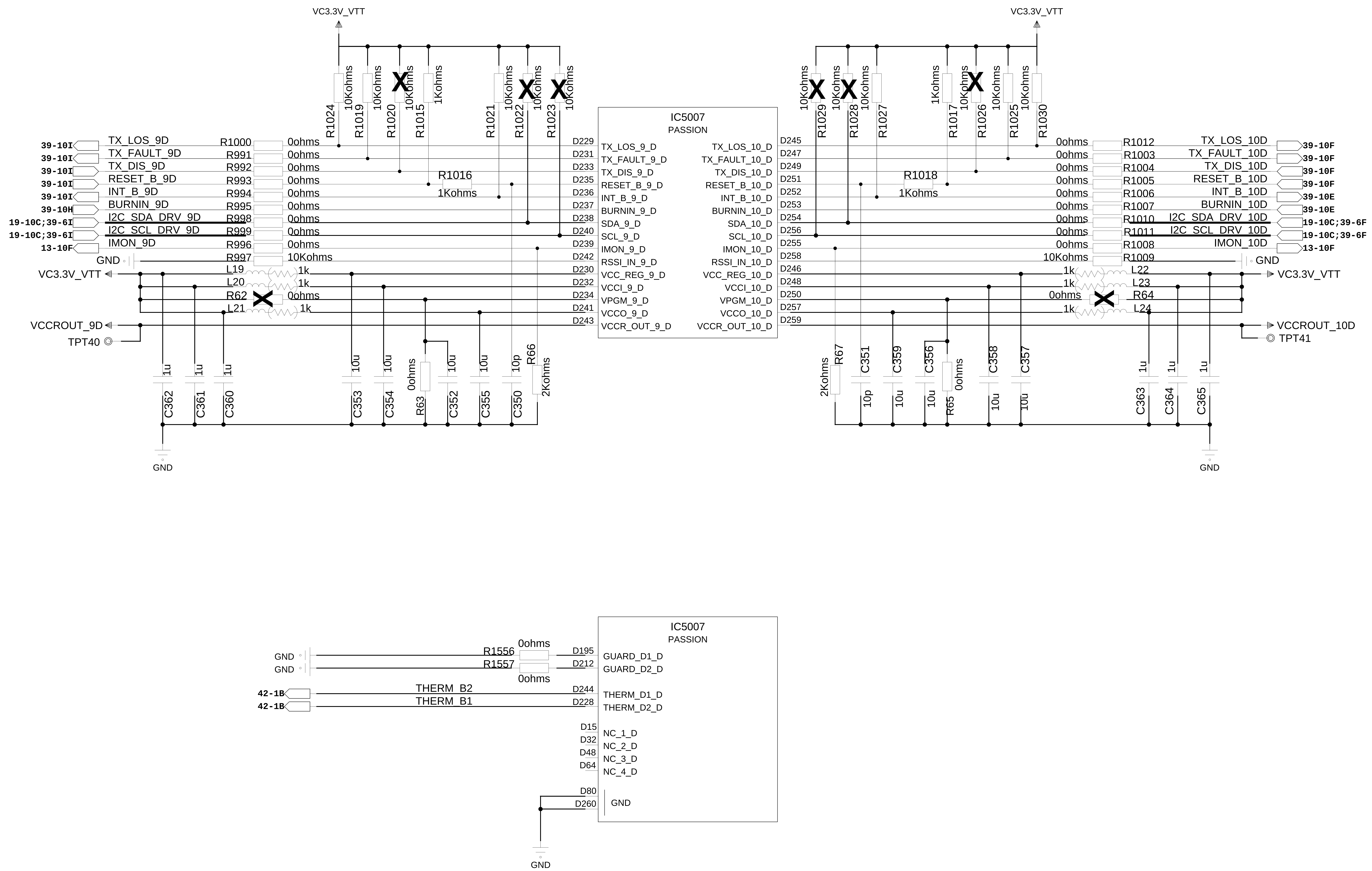

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Document id: ESKC61024

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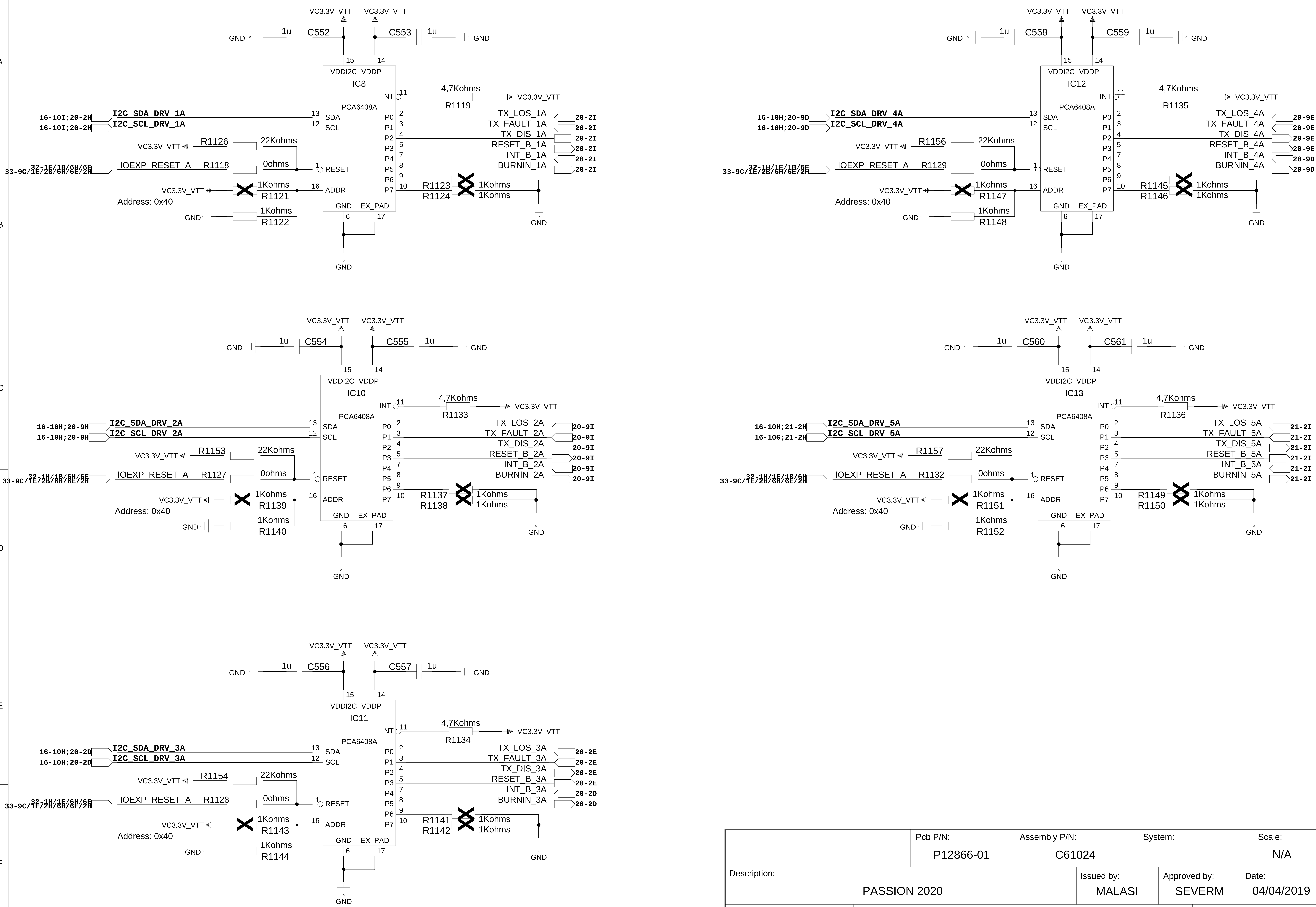

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Document id: ESKC61024

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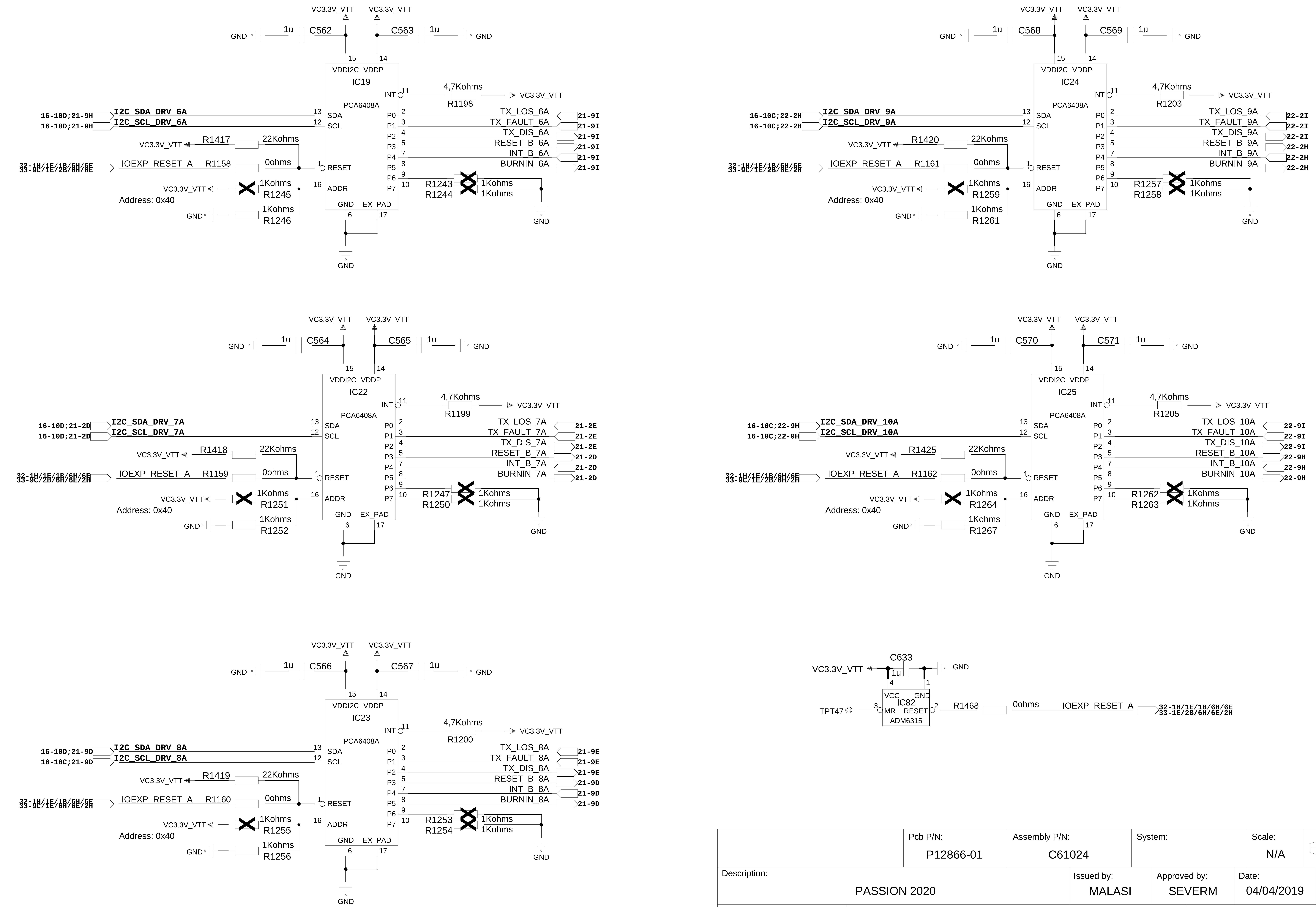

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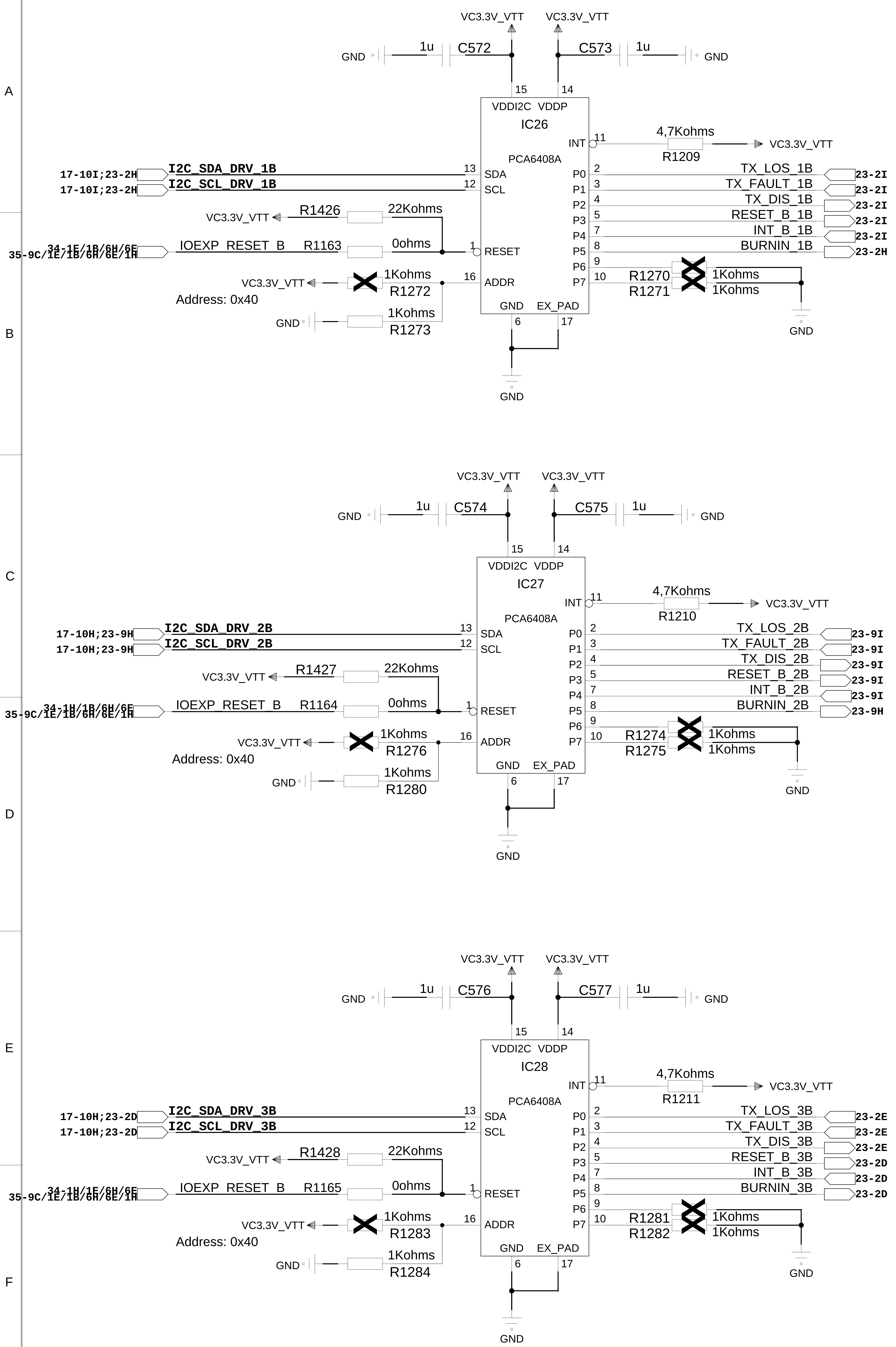

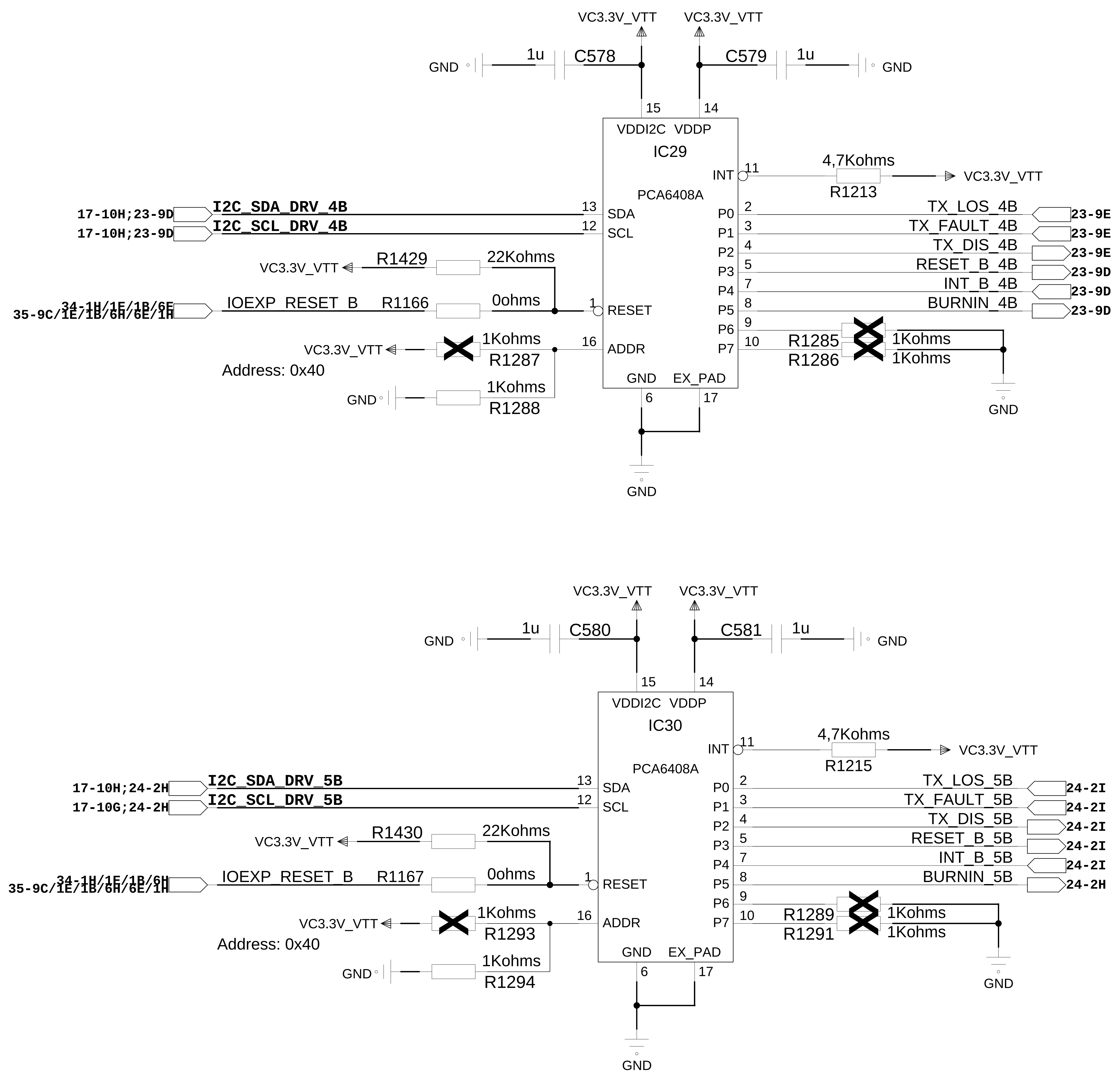

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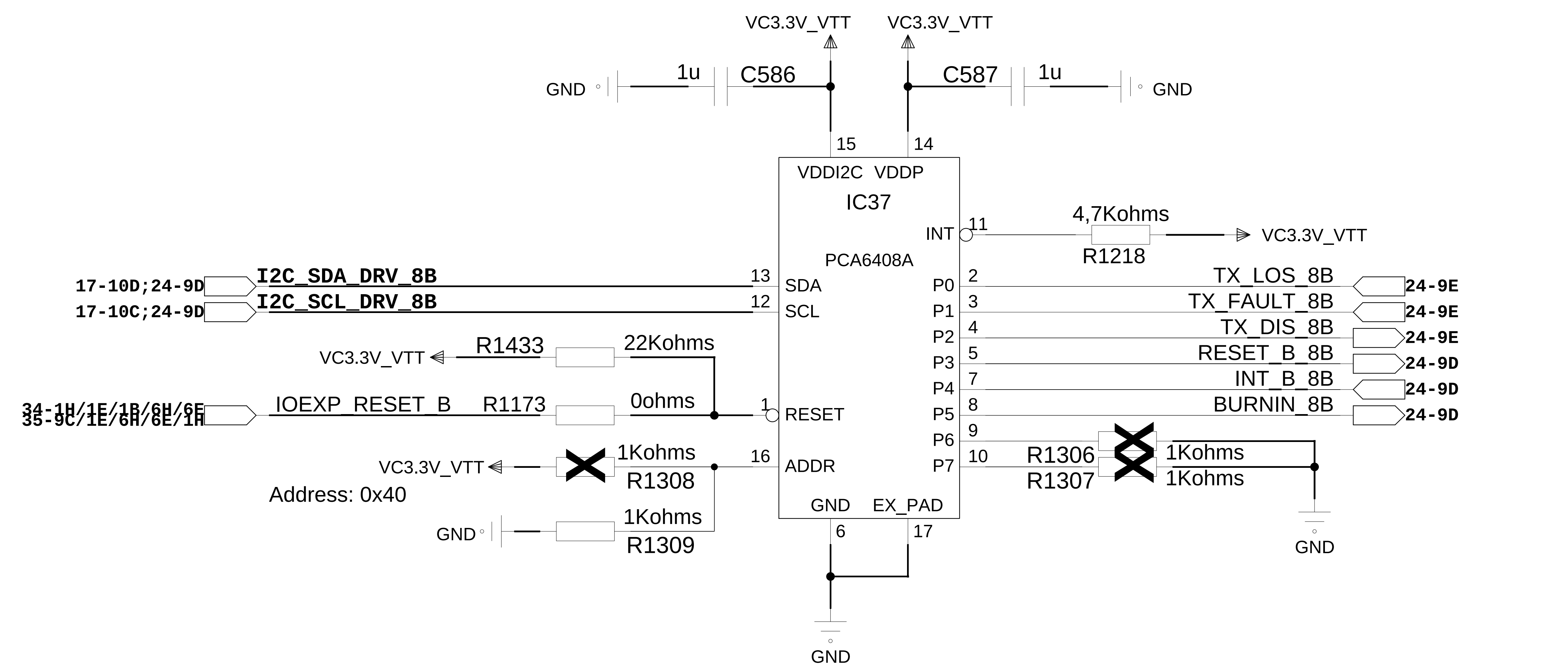

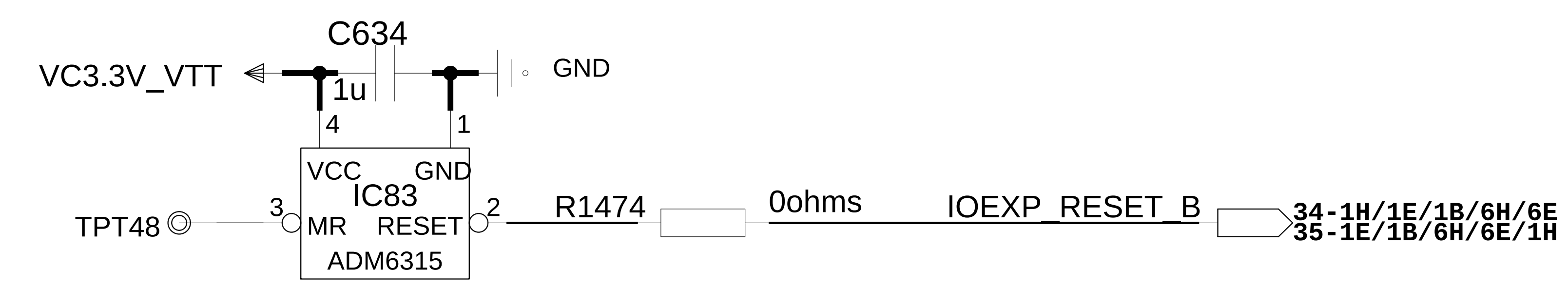

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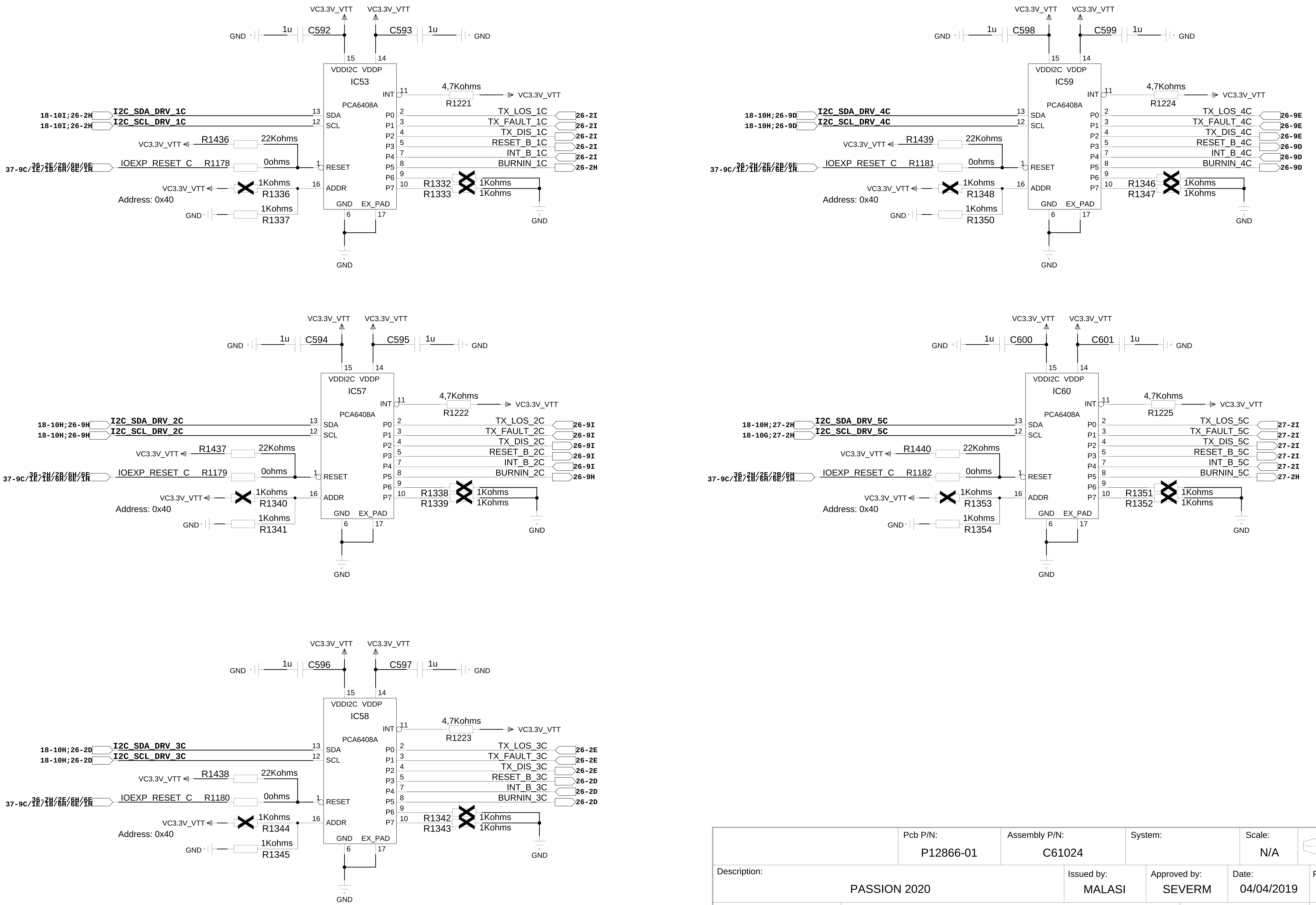

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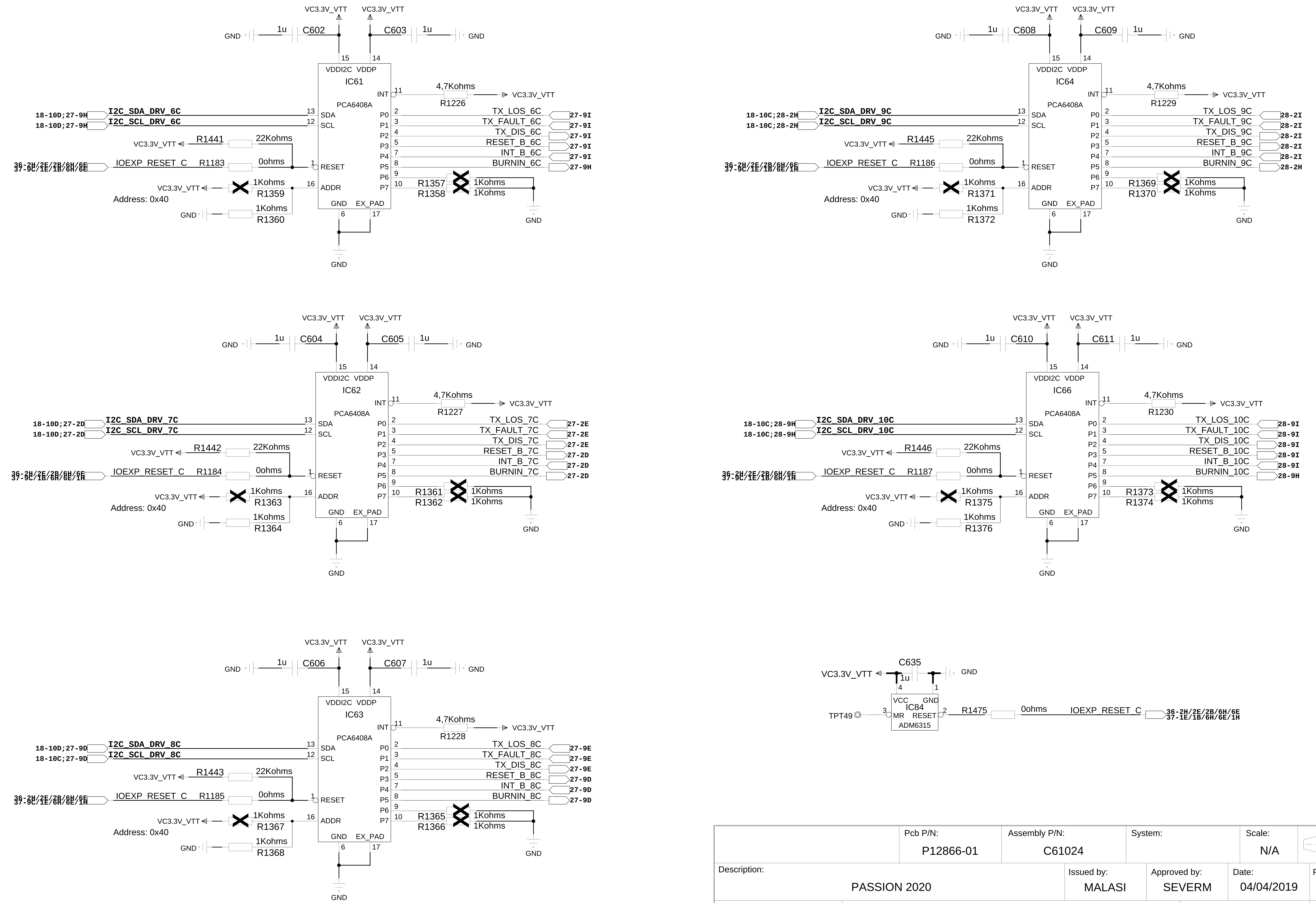

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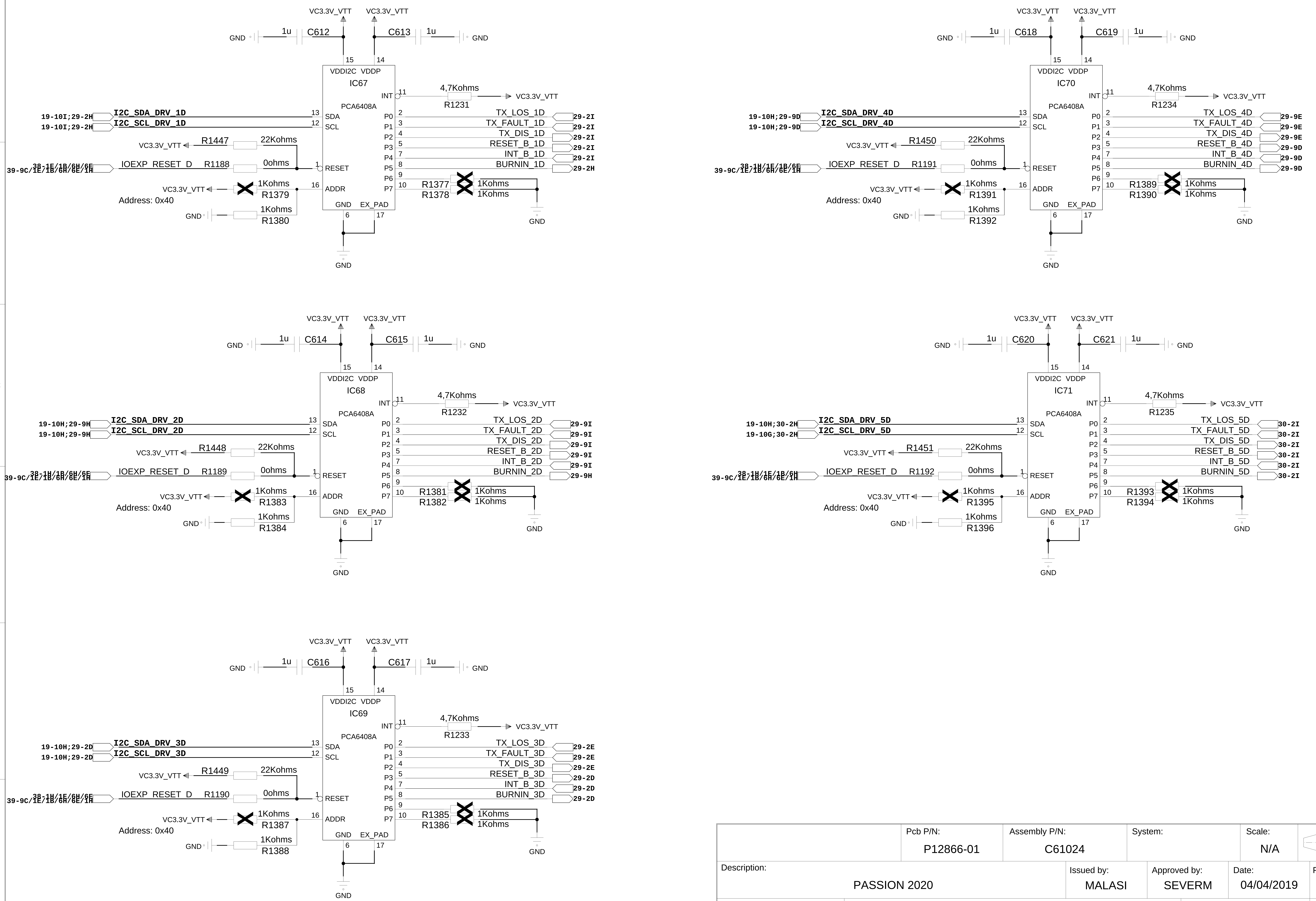

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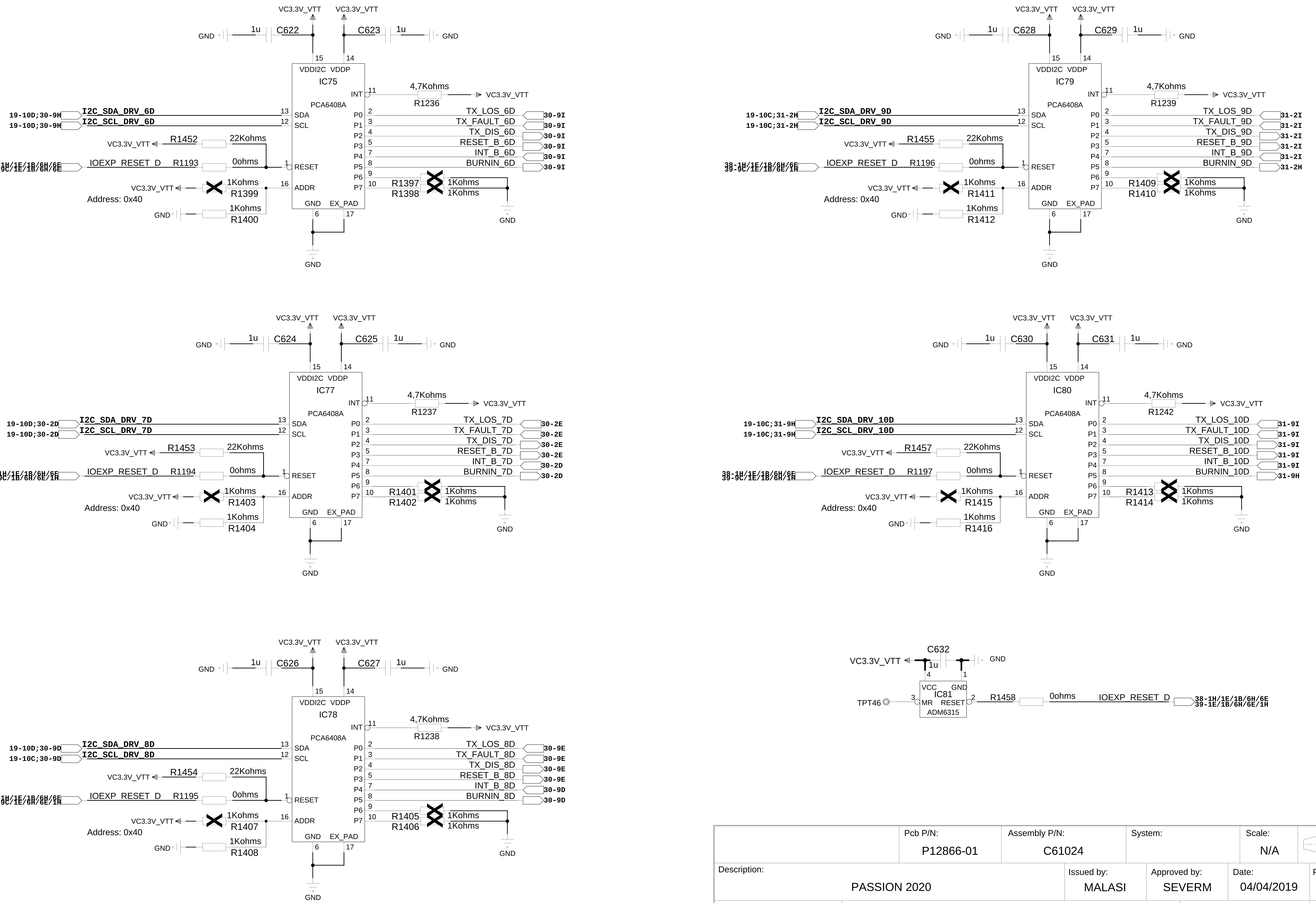
		Document id:	Revision:
	sm optics siae microelettronica group	ESKC61024	01



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PASSION 2020	MALASI	SEVERM	04/04/2019	39 / 51

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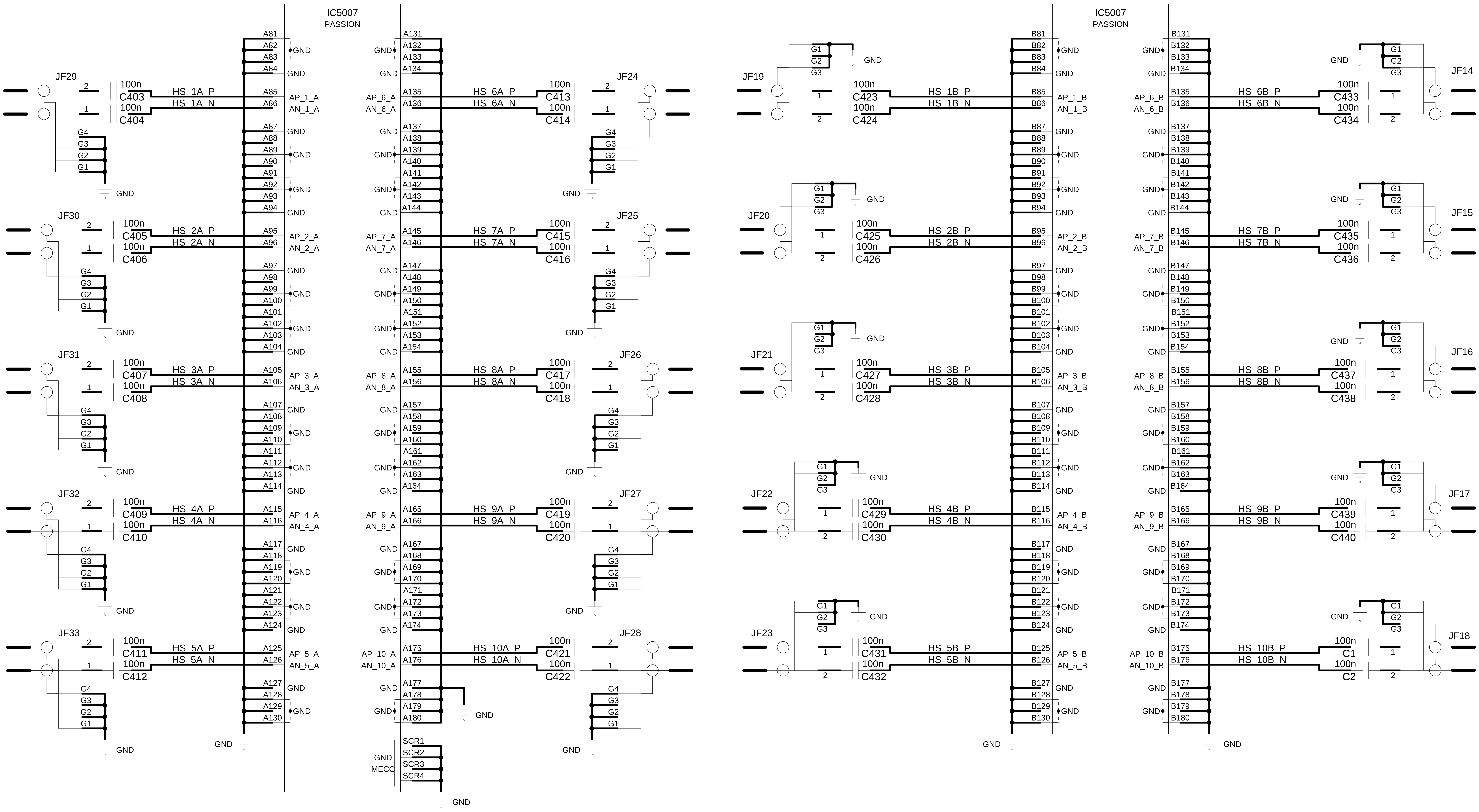

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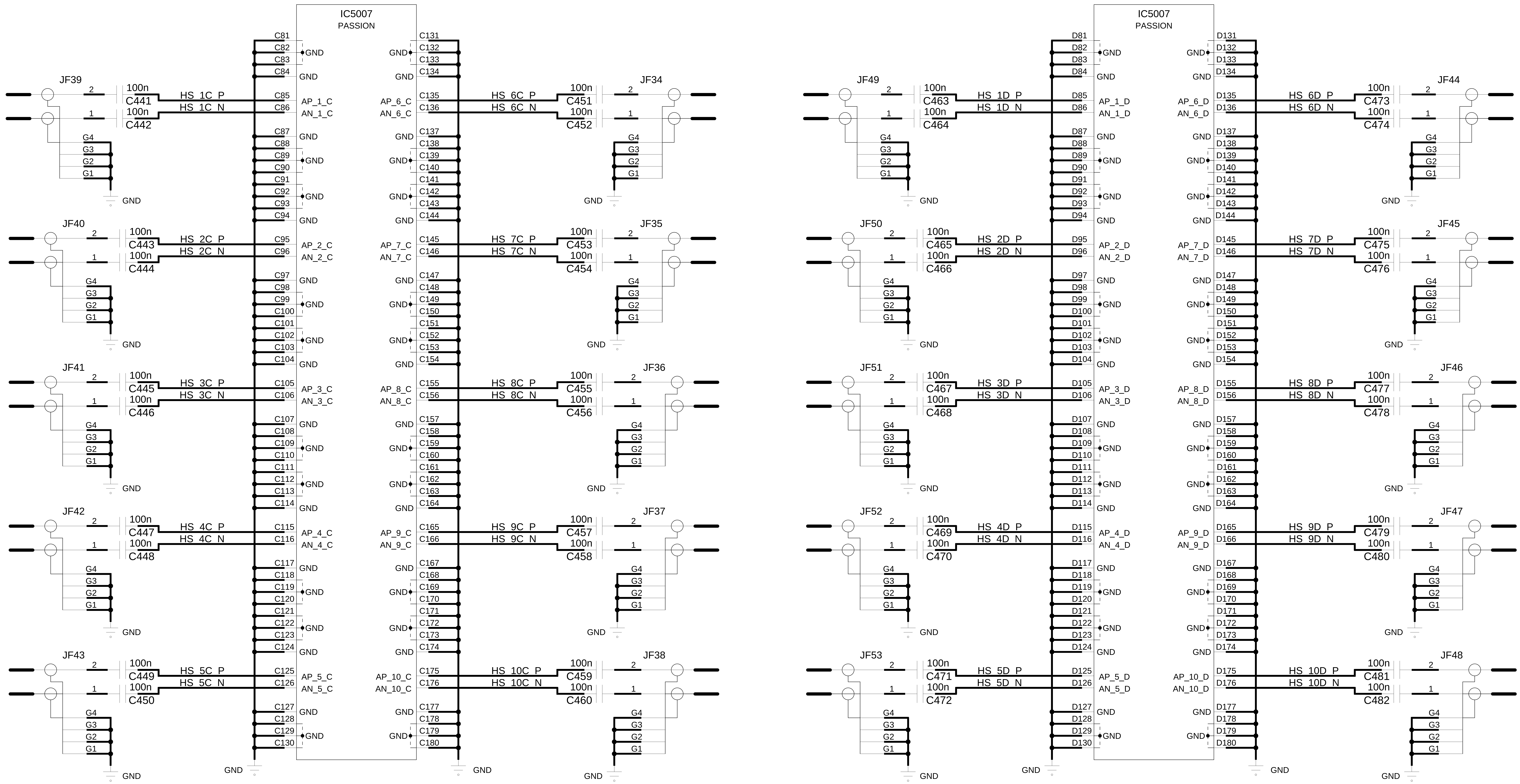

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Description: PASSION 2020	Issued by: MALASI	Approved by: SEVERM	Date: 04/04/2019	Page: 41 / 51
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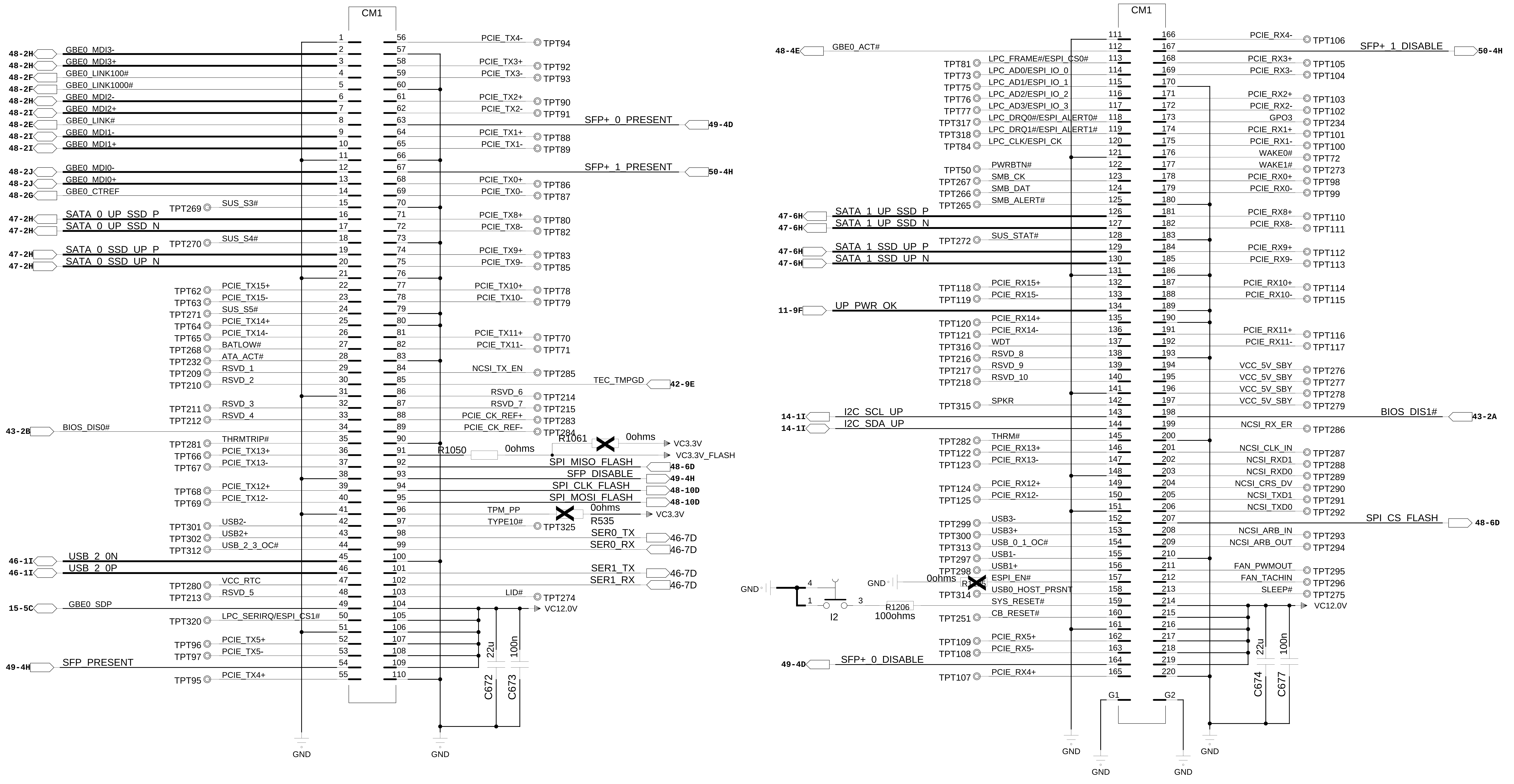
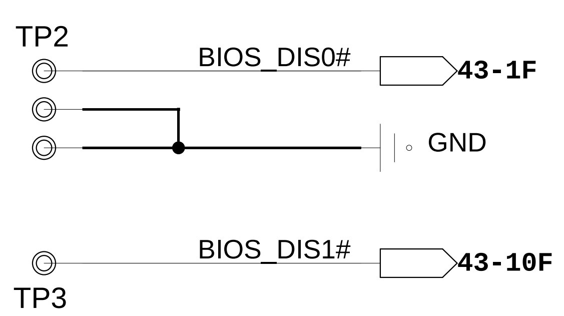


TP2 E TP3 devono avere passo 2.54mm
e devono essere accessibili dal TOP



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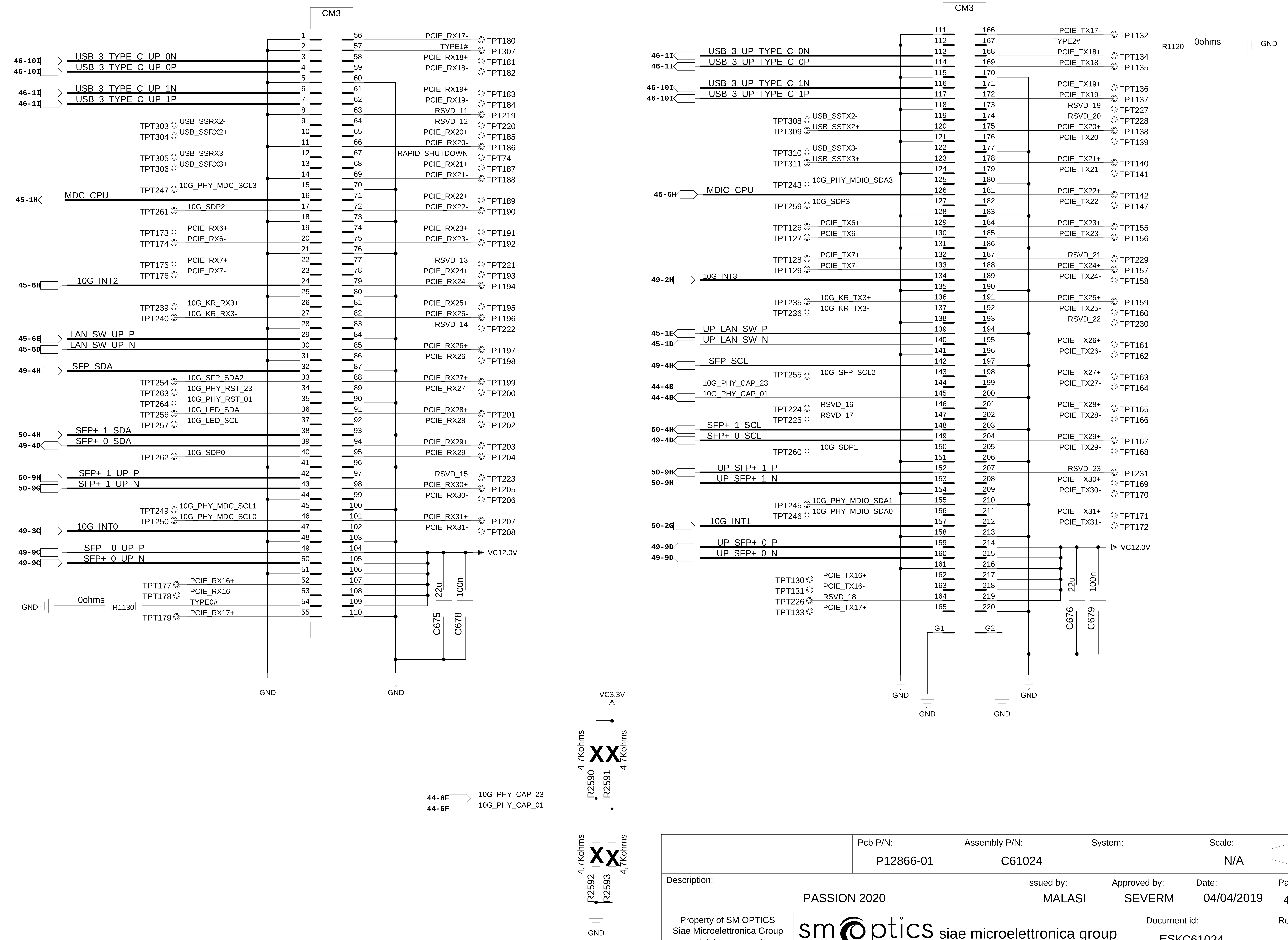

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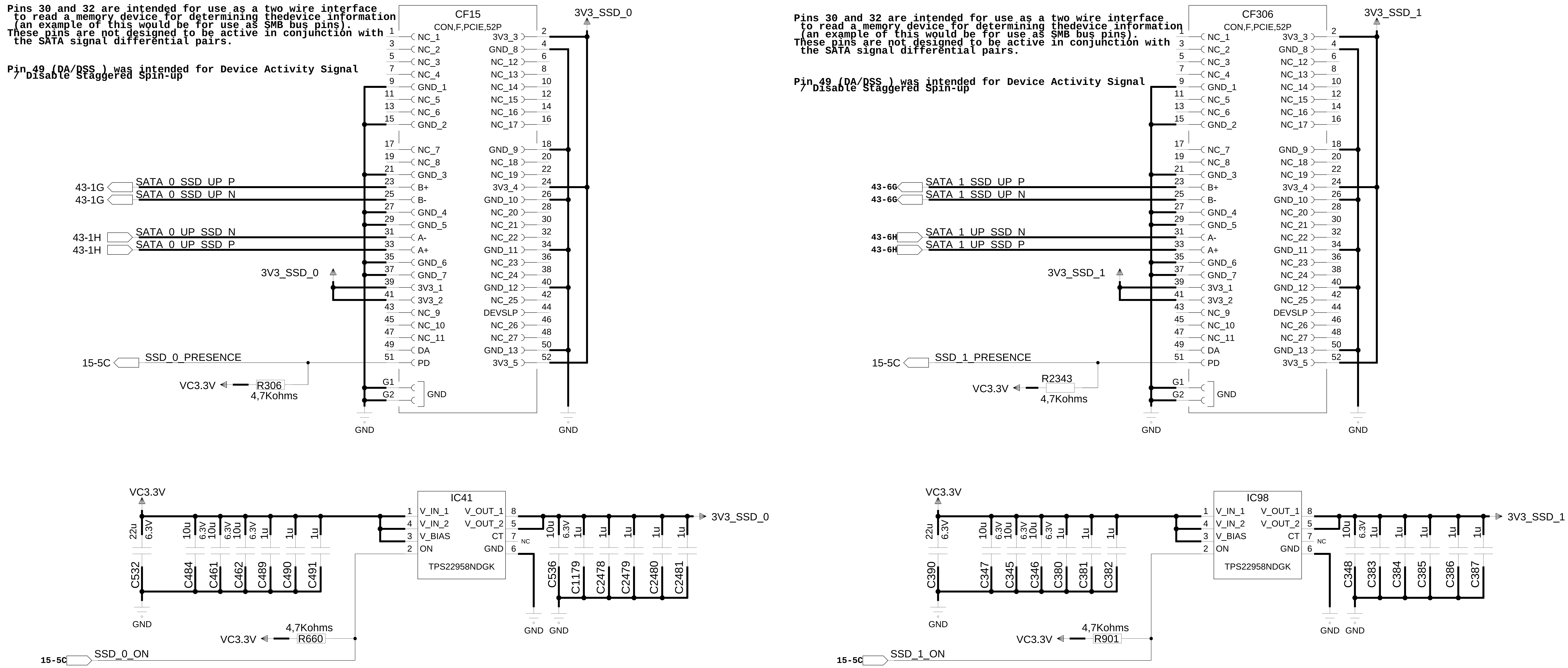

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Description: PASSION 2020	Issued by: MALASI	Approved by: SEVERM	Date: 04/04/2019	Page: 47 / 51
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Description:	Issued by:	Approved by:	Date:	Page:
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Description: PASSION 2020	Issued by: MALASI	Approved by: SEVERM	Date: 04/04/2019	Page: 49 / 51
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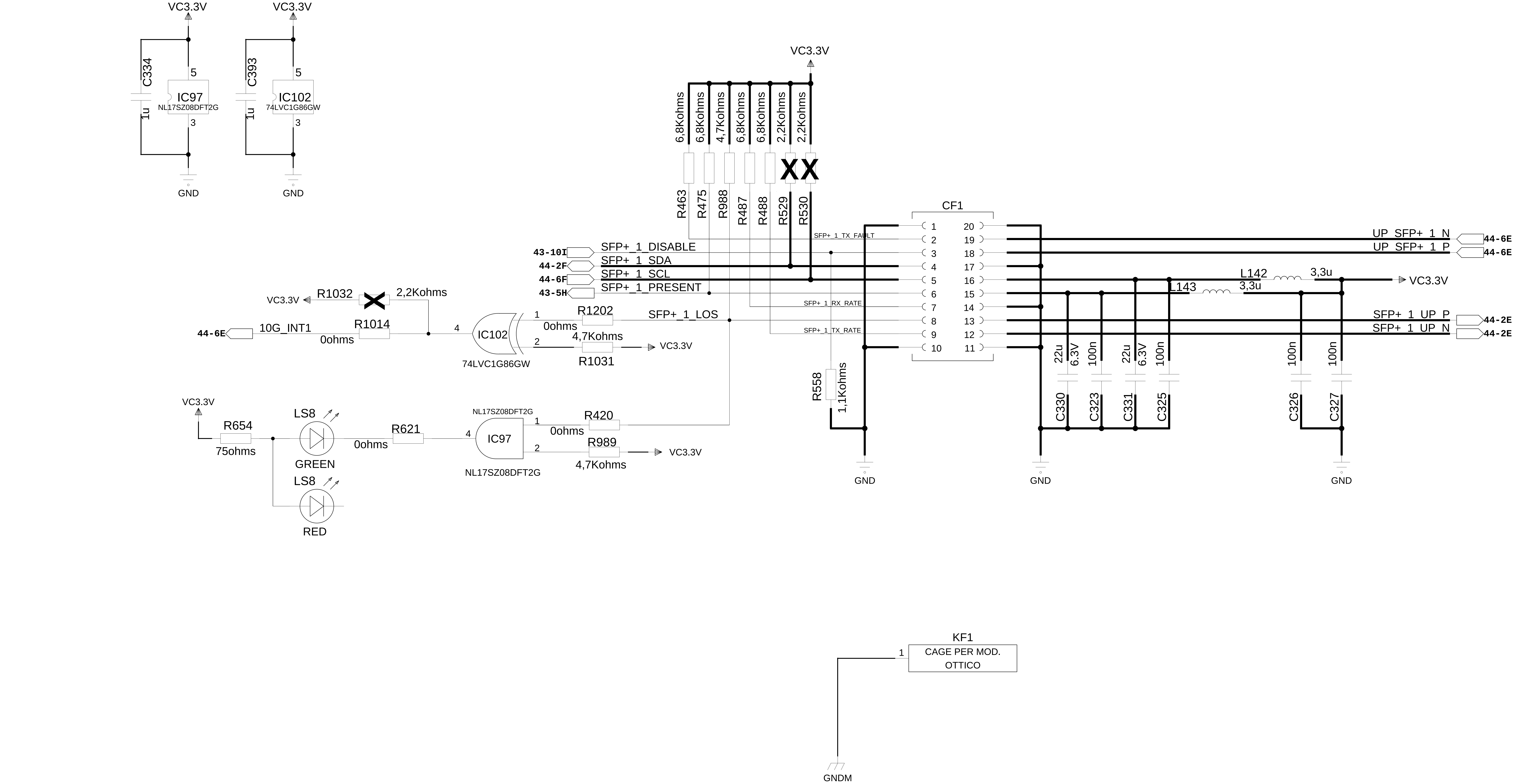

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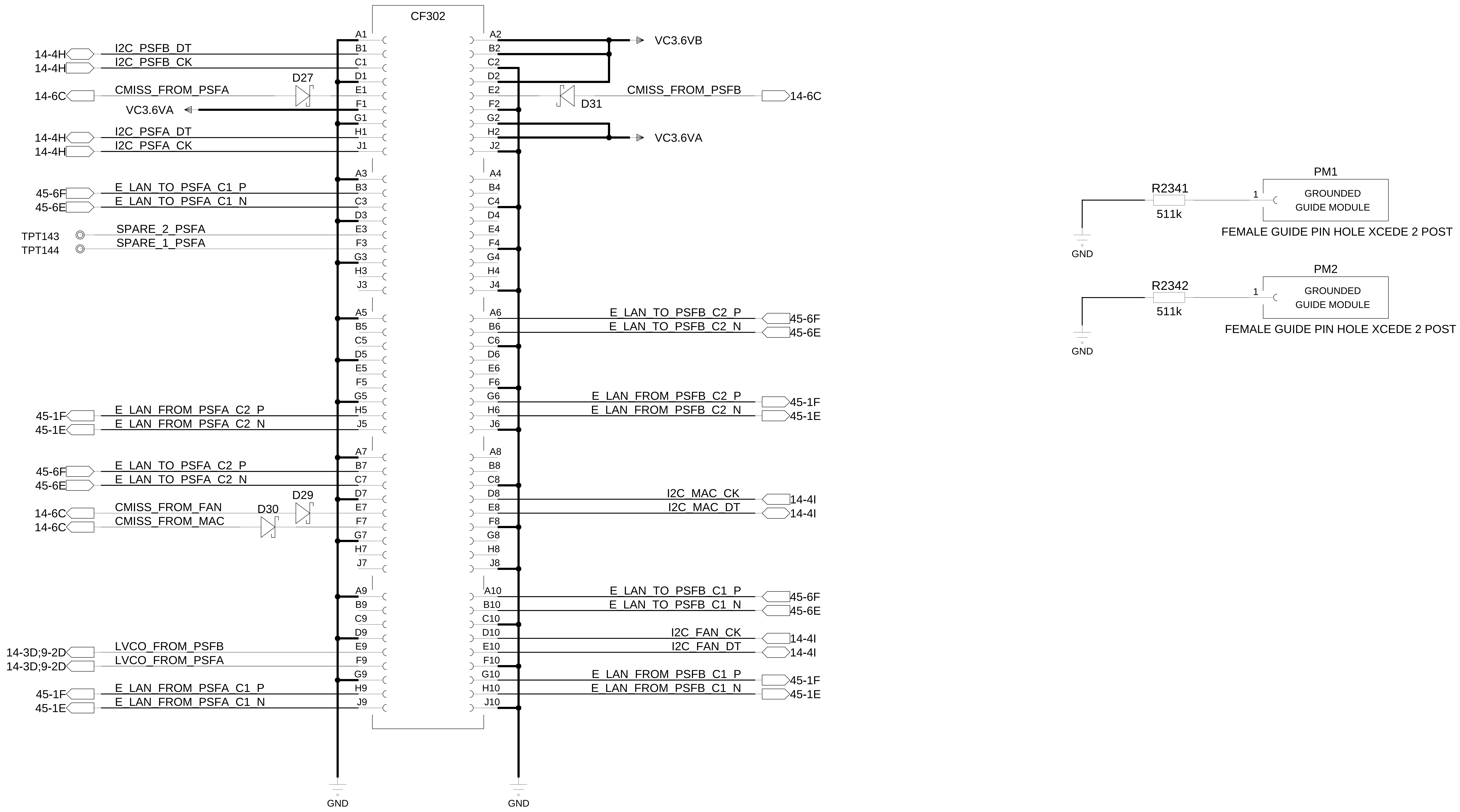
	sm optics siae microelettronica group		Document id: ESKC61024	Revision: 01

UT_modA3_SMO rev.001 25-02-16



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Description: PASSION 2020	Issued by: MALASI	Approved by: SEVERM	Date: 04/04/2019	Page: 51 / 51
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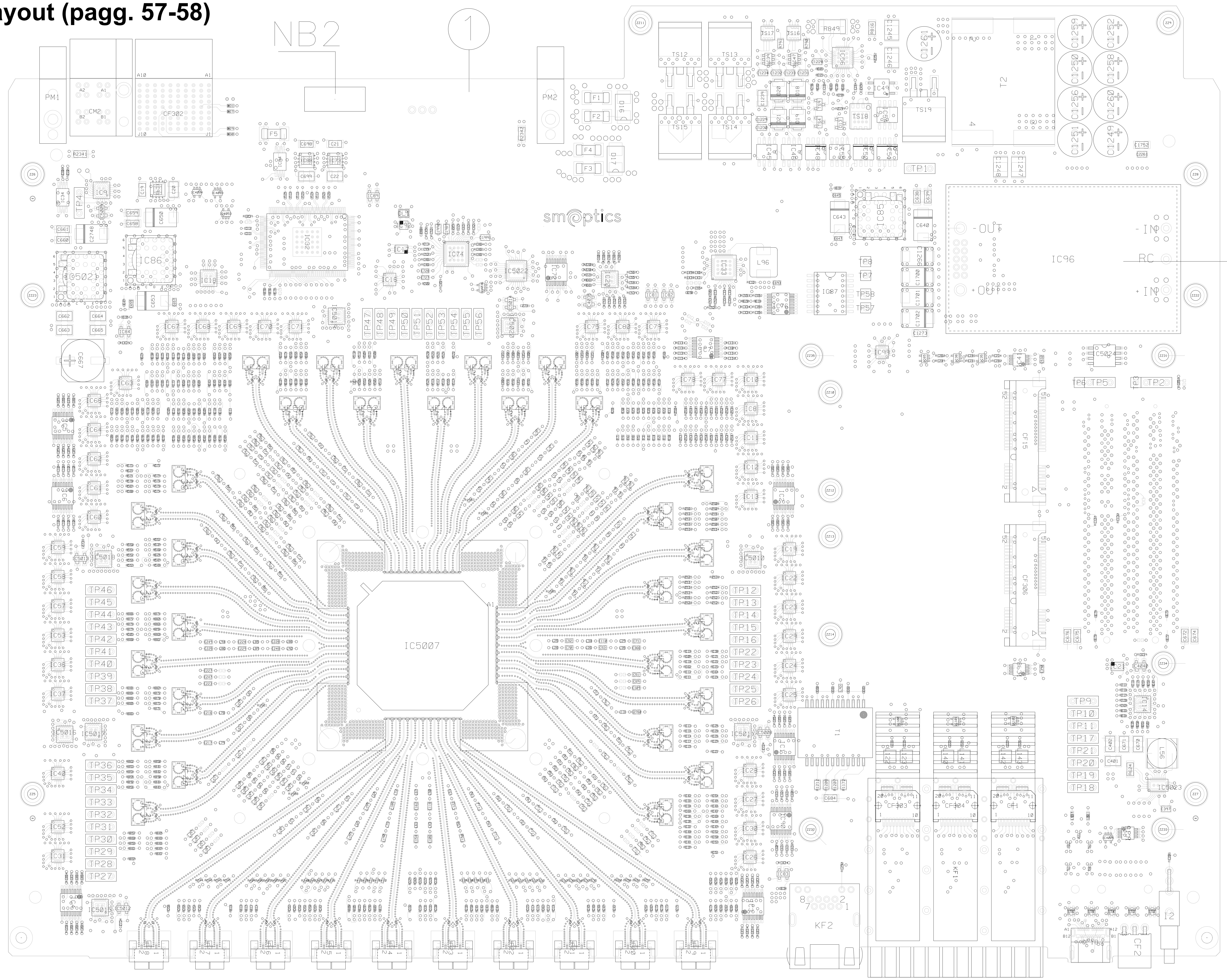
8.1.4 PCB Layout (pagg. 57-58)



NB1: IF NOT OTHERWISE SPECIFIED, MAXIMUM LEADS PROTRUSION (rheophores) HEIGHT 1.4 mm. TRIM THE EXCESSIONS BEFORE WELDING
NOT TRIM FOR PRESS FIT MOUNTING COMPONENTS

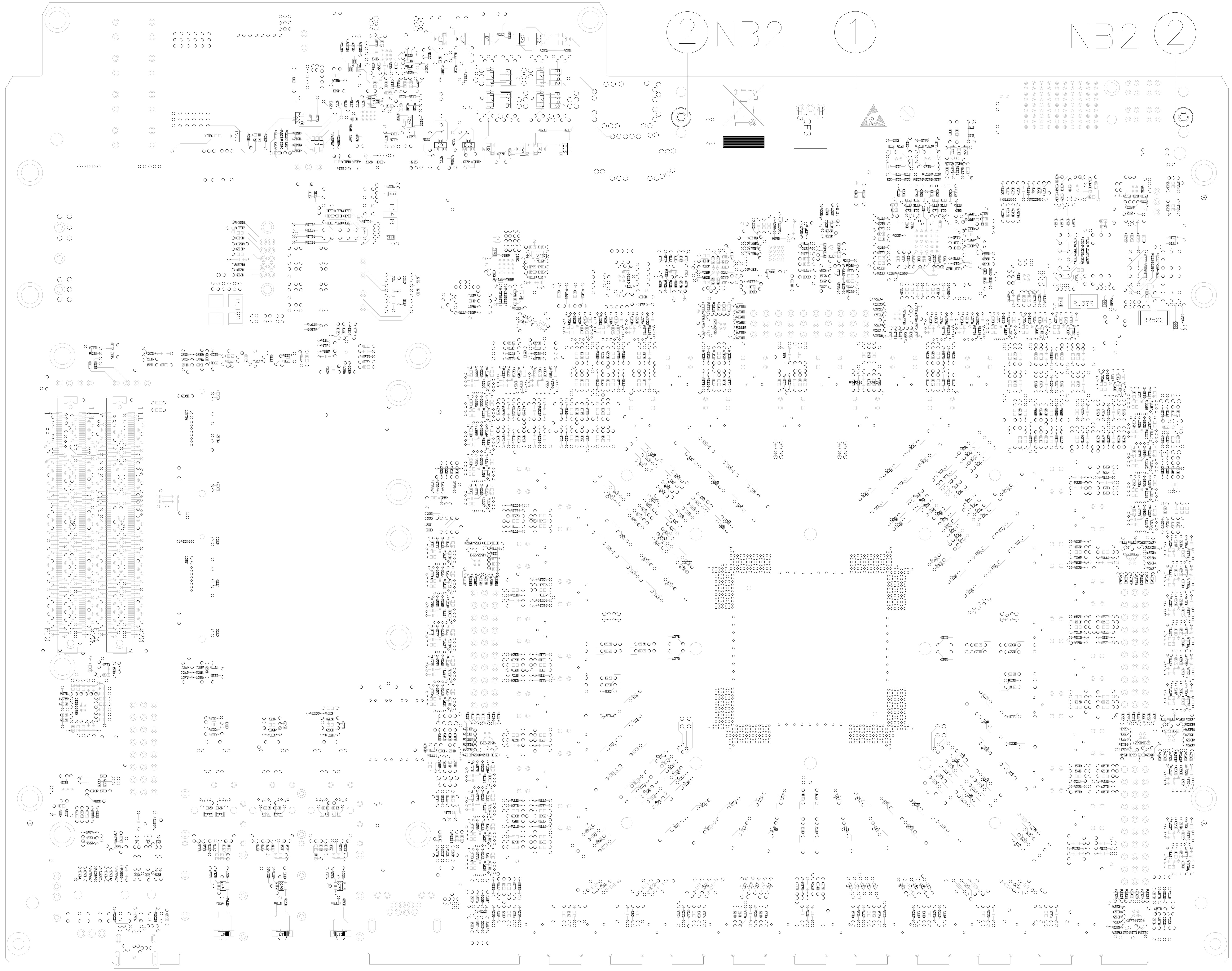
NB2: FILL IDENTIFICATION LABEL AS PER NG.00503 ETI0807 OR ETI0808 AND APPLY AS DRAWING.

NB3: PUT REFERENCE 3 UNDER IC96 COMPONENT BEFORE ASSEMBLY

Units : Millimeters	Pcb P/N: P12866-01	Assembly P/N: C61024	System P/N: OTN CARD	Not to Scale
Description: PASSION-MOD1 TX MODULE EVALUATION BOARD	Issued by: BOTTOE	Approved by: COLOMW	Date: 29-09-2020	Page: 1/ 2
Property of SM Optics all rights reserved	smoptics		Document Id: TES.C61024	Revision: 01

1 2 3 4 5 6 7 8

② NB2 ① NB2 ② LAYER 16



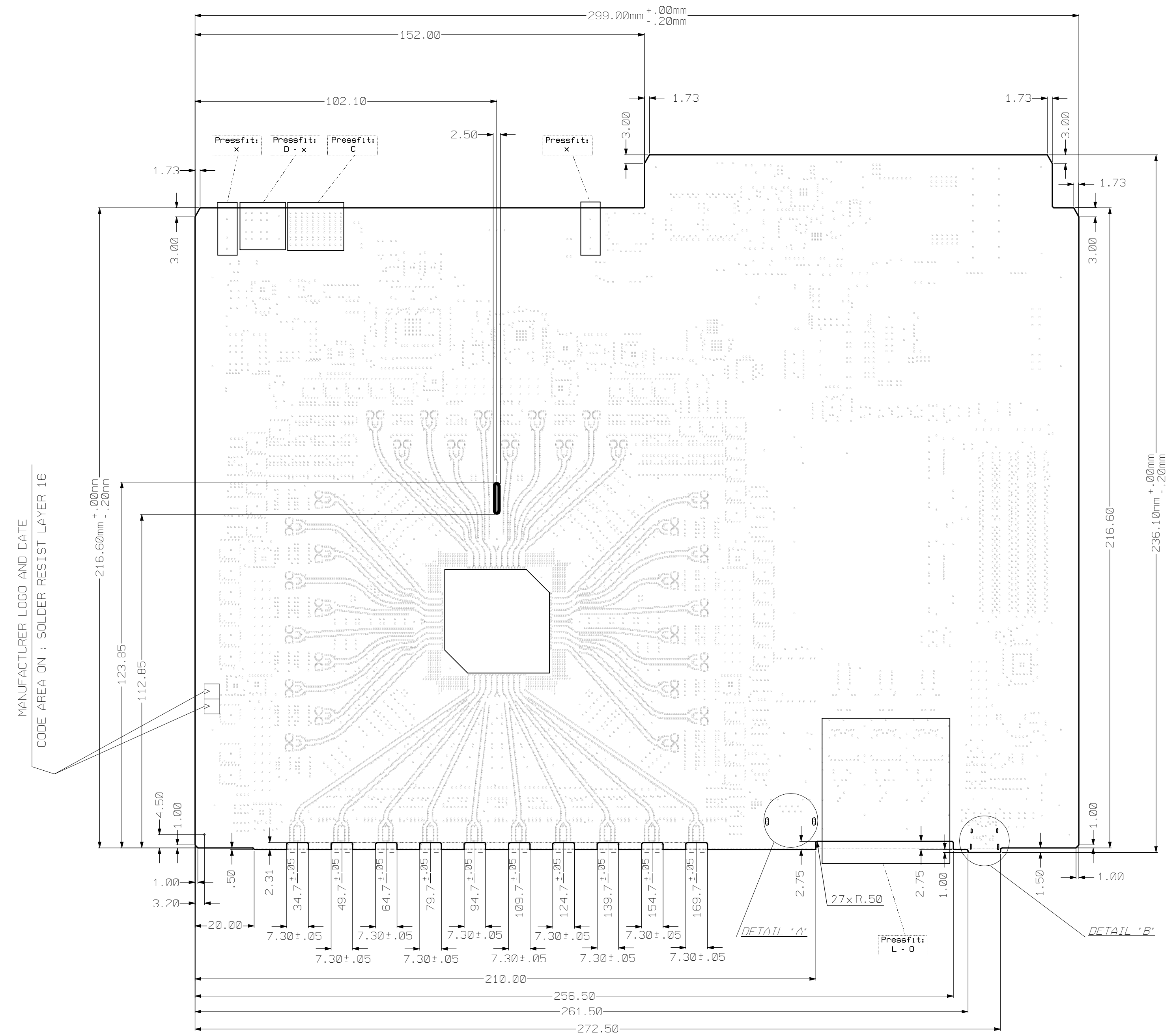
NB1: IF NOT OTHERWISE SPECIFIED, MAXIMUM LEADS PROTRUSION (rheophores) 1.4 mm
TRIM THE EXCESS BEFORE WELDING.
TRIM NOT ALLOWED FOR PRESS-FIT COMPONENTS

NB2: TIGHTENING TORQUE 0,16 Nm

" ONLY LEAD FREE PROCESS "

Units : Millimeters	Pcb P/N: P12866-01	Assembly P/N: C61024	System P/N: OTN CARD	Not to Scale	
Description: PASSION-MOD1 TX MODULE EVALUATION BOARD		Issued by: BOTTOE	Approved by: COLOMW	Date: 29-09-2020	Page: 2 / 2
Property of SM Optics all rights reserved	smoptics		Document Id: TES.C61024		Revision: 01

1.1.5 PCB Requirements (59-65)



BUILDING LAY-UP

Via laser_1-2

Bkd_1-12

Layer	Material	Cloth style	Resin content %	Thickness [um]	Copper foil Profile	Copper foil Grades
Solder Mask						
TOP 1	Base Copper			12		HTE
	Prepreg GHA-679G (S) S1078N69	1-1078	69	91		
2	Base Copper			17	RTF	
	Core MCL-HE-679G (S)	2-1078	57	127		
3	Base Copper			17	RTF	
	Prepreg GHA-679G (S) S1067N69	2-1067	69	120		
4	Base Copper			17	RTF	
	Core MCL-HE-679G (S)	2-1078	57	127		
5	Base Copper			17	RTF	
	Prepreg GHA-679G (S) S1067N69	2-1067	69	120		
6	Base Copper			17	RTF	
	Core MCL-HE-679G (S)	2-1078	57	127		
7	Base Copper			17	RTF	
	Prepreg GHA-679G (S) S1067N69	2-1067	69	120		
8	Base Copper			17	RTF	
	Core MCL-HE-679G (S)	2-1037	71	102		
9	Base Copper			17	RTF	
	Prepreg GHA-679G (S) S1067N69	2-1067	69	120		
10	Base Copper			17	RTF	
	Core MCL-HE-679G (S)	2-1078	57	127		
11	Base Copper			17	RTF	
	Prepreg GHA-679G (S) S1067N69	2-1067	69	120		
12	Base Copper			17	RTF	
	Core MCL-HE-679G (S)	2-1078	57	127		
13	Base Copper			17	RTF	
	Prepreg GHA-679G (S) S1067N69	2-1067	69	120		
14	Base Copper			17	RTF	
	Core MCL-HE-679G (S)	2-1078	57	127		
15	Base Copper			17	RTF	
	Prepreg GHA-679G (S) S1078N69	1-1078	69	91		
BOT 16	Base Copper			12		HTE
Solder Mask						

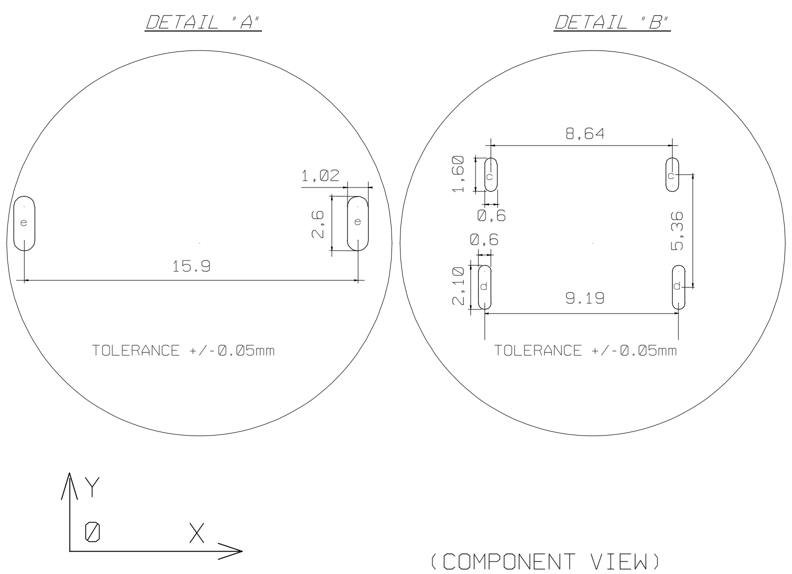
2,00 mm +/-10%

OVER PLATING (excluding solder mask)

FINISHING : Immersion Silver / Immersion Gold (ISIG)

LAMINATE : N00550 - HITACHI MCL-HE-679G (S) GLASS SOURCE ASAHI OR NANYA

BACKDRILL LEVEL SEE PAGES 7/7



NC Drill Chart Span 1-2
Board Holes

Symbol	Diameter	Plated	Quantity	Tolerance	Note
E	0.10	Yes	8195		

Through Holes
Board Holes

Symbol	Diameter	Plated	Quantity	Tolerance	Note
F	0.20	Yes	1714		
B	0.25	Yes	183		
G	0.30	Yes	4261		
C	0.39	Yes	90	+0.04/-0.04	Pressfit
A	0.65	Yes	120	+0.05/-0.05	P.I.P.
H	0.70	Yes	77		
D	0.72	Yes	16	+0.08/-0.05	Pressfit
J	0.85	Yes	162		
L	0.97	Yes	14	+0.05/-0.05	Pressfit
M	1.00	Yes	36		
O	1.04	Yes	14	+0.05/-0.05	Pressfit
P	1.10	Yes	8		
f	1.20	Yes	6		
R	1.40	Yes	3		
U	2.08	Yes	2		
X	2.50	Yes	3	+0.05/-0.05	Pressfit
Y	2.70	Yes	2		
b	4.24	Yes	17	+0.1/-0	
I	0.71	No	20		
K	0.85	No	2		
N	1.00	No	2	+0.025/-0	SEE PAGE 6/7 FOR DETAIL
Q	1.10	No	2		
S	1.60	No	10		
T	2.00	No	3		
V	2.30	No	1		
W	2.40	No	4		
Z	2.70	No	4		
a	3.00	No	12	+0.05/-0	Tooling Holes
c	0.60	Yes	2		Plated Slot (1.60 x 0.60 +/- 0.05)
d	0.60	Yes	2		Plated Slot (2.10 x 0.60 +/- 0.05)
e	1.02	Yes	2		Plated Slot (2.6 x 1.02+/-0.05)

NOTE 1: CONDUCTOR WIDTH ON LAYERS 1-3-5-7-10-12-13-14-16 AS PER PA.00809 LEVEL C
NOTE 2: PCB WITH CONTROLLED IMPEDANCE
NOTE 3: MINIMUM CONDUCTOR WIDTH : 4 mils
NOTE 4: MINIMUM CONDUCTOR SPACING : 4 mils
NOTE 5: PWB AREA : cmq 706
NOTE 6: PANEL YES, FOR DETAIL SEE DOCUMENT QML.P12866-01

THIS PCB MUST COMPLY WITH ALL APPLICABLE REQUIREMENTS INDICATED IN PA.00809

Units : Millimeters	Pcb P/N: P12866-01	Assembly P/N : C61024	System P/N : SMO	Not to Scale
Description : PASSION-MOD1	Issued by : Crippf	Approved by : Cesane	Date : 18-09-2020	Page : 1-7
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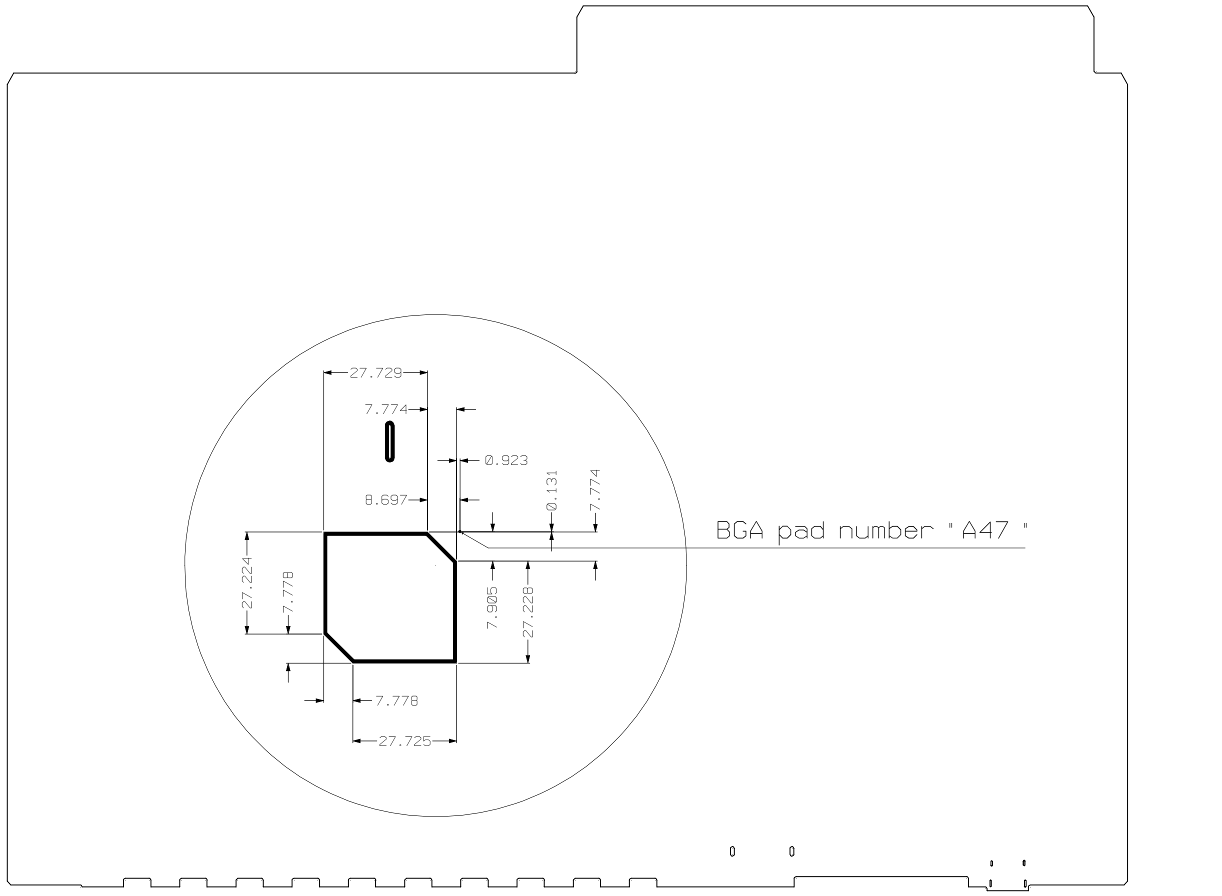
IMPEDANCE TRACE LAYOUT

Layer	Edge-Coupled 100 ohm HF +/- 7%		Edge-Coupled 95 ohm +/- 10%		Single Ended 50 ohm +/- 10%
	Line width [um]	Spacing * [um]	Line width [um]	Spacing * [um]	Line width [um]
TOP 1	127 (5.0 mils)	101.6 (4.0mils)	144.78 (5.7mils)	185.42 (7.3mils)	165.1 (6.5mils)
2					
3			114.3 (4.5mils)	177.8 (7.0mils)	111.8 (4.4mils)
4					
5			114.3 (4.5mils)	177.8 (7.0mils)	111.8 (4.4mils)
6					
7					111.8 (4.4mils)
8					
9					
10			114.3 (4.5mils)	177.8 (7.0mils)	111.8 (4.4mils)
11					
12			114.3 (4.5mils)	177.8 (7.0mils)	111.8 (4.4mils)
13					
14			114.3 (4.5mils)	177.8 (7.0mils)	111.8 (4.4mils)
15					
BOT 16			144.78 (5.7mils)	185.42 (7.3mils)	165.1 (6.5mils)

* spacing is defined as copper to copper spacing, not center to center spacing



CAVITY DIMENSION AND POSITION

NOTE 1: Cavity shall be milled when Outer layers have been etched with their final pattern

NOTE 2: Coordinates origin location is BGA pad "A47" (reference point)

NOTE 3: Tolerance for all dimension must be +/-0.050 mm or better

NOTE 4: All the cavity milling radius are 0.50 mm

Y
0 X

(COMPONENT VIEW)

THIS PCB MUST COMPLY WITH ALL APPLICABLE REQUIREMENTS INDICATED IN PA.00809

Units : Millimeters	Pcb P/N P12866-01	Assembly P/N : C61024	System P/N : SMO	Not to Scale
Description : PASSION-MOD1	Issued by : Crippf	Approved by : Cesane	Date : 18-09-2020	Page : 2-7
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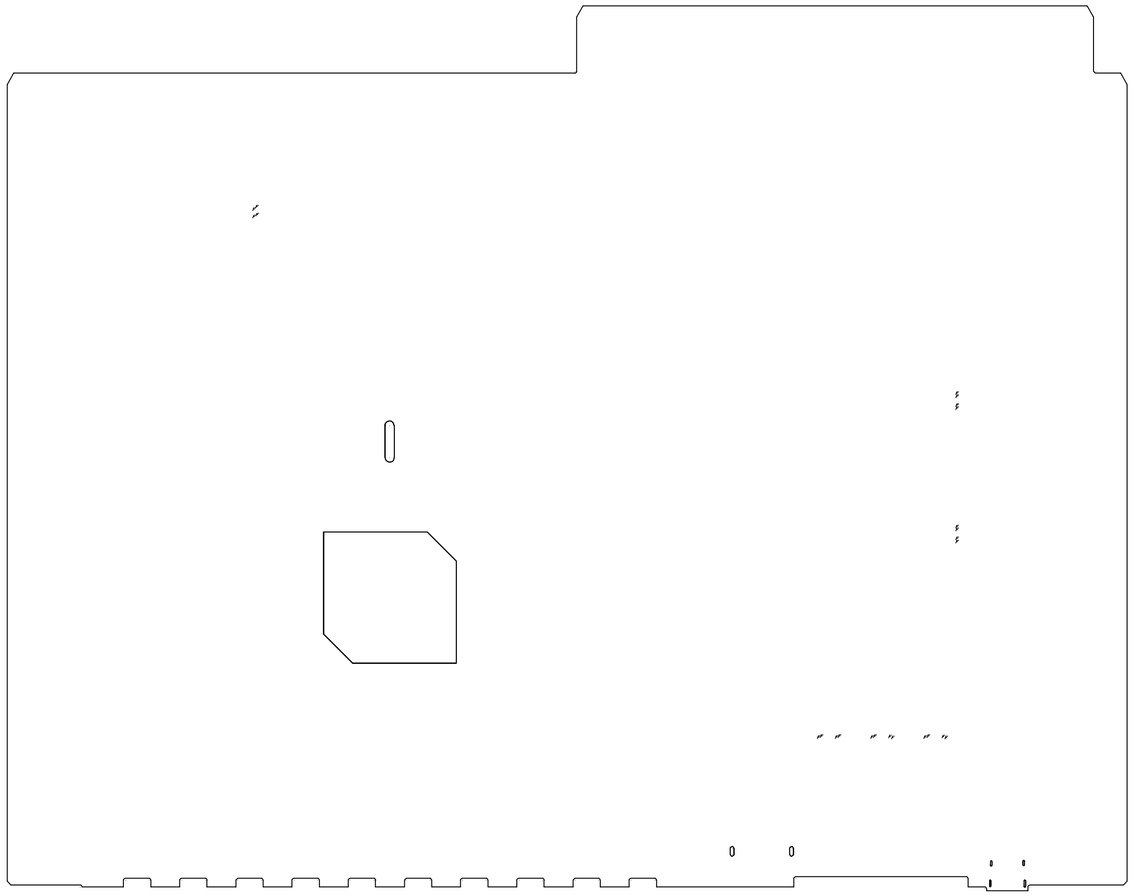
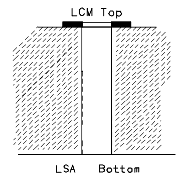


Through Holes				
Symbol	Diameter	Plated	Quantity	
F	0.20	Yes	24	

NOTE 1: ALL PLATED THROUGH HOLES INDICATED IN DRILL TABLE
ARE MADE WITHOUT PAD ON BOTTOM

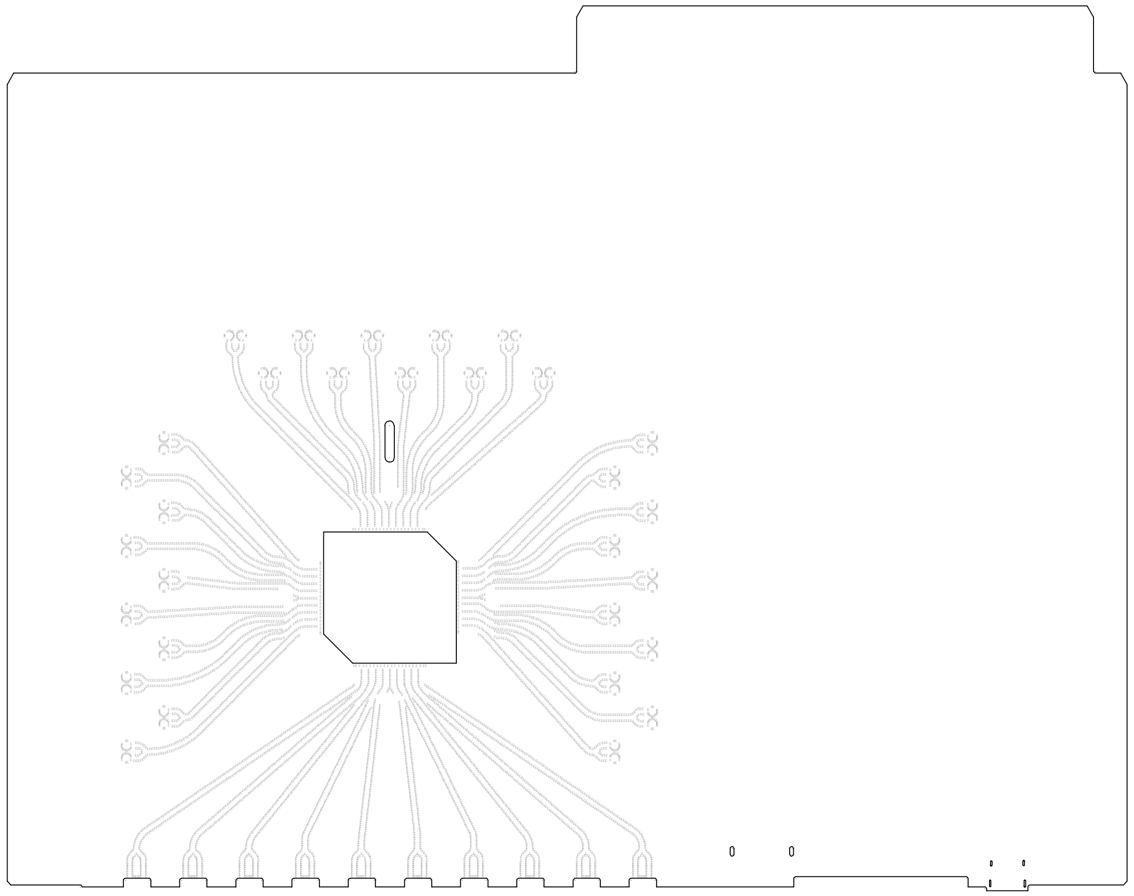
Suppress pad on layer Bottom (ly16)

Y
Ø X

(COMPONENT VIEW)

THIS PCB MUST COMPLY WITH ALL APPLICABLE REQUIREMENTS INDICATED IN PA.00809

Units : Millimeters	Pcb P/N P12866-01	Assembly P/N : C61024	System P/N : SMO	Not to Scale
Description : PASSION-MOD1	Issued by : Crippf	Approved by : Cesane	Date : 18-09-2020	Page : 3-7
	smoptics siae microelettronica group		Document ID : DRP. P12866-01	Revision 01



NOTE 1: LASER BLIND MICROVIA HOLES INDICATED IN DRILL TABLE
ARE MADE WITHOUT FILLED AND CAPPED PROCESS

NOTE 2: MICROVIA PLATING SHALL MEET THE REQUIREMENTS OF
IPC-6012 CLASS 3
(12 um AVG MINIMUM. 10 um ABSOLUTE MINIMUM)

NC Drill Chart Span 1-2
Board Holes

Symbol	Diameter	Plated	Quantity	Tolerance	Note
E	0.10	Yes	8195		

Y
0 X

(COMPONENT VIEW)

THIS PCB MUST COMPLY WITH ALL APPLICABLE REQUIREMENTS INDICATED IN PA.00809

Units : Millimeters	Pcb P/N P12866-01	Assembly P/N : C61024	System P/N : SMO	Not to Scale	
Description : PASSION-MOD1	Issued by : Crippf	Approved by : Cesane	Date : 18-09-2020	Page : 4-7	
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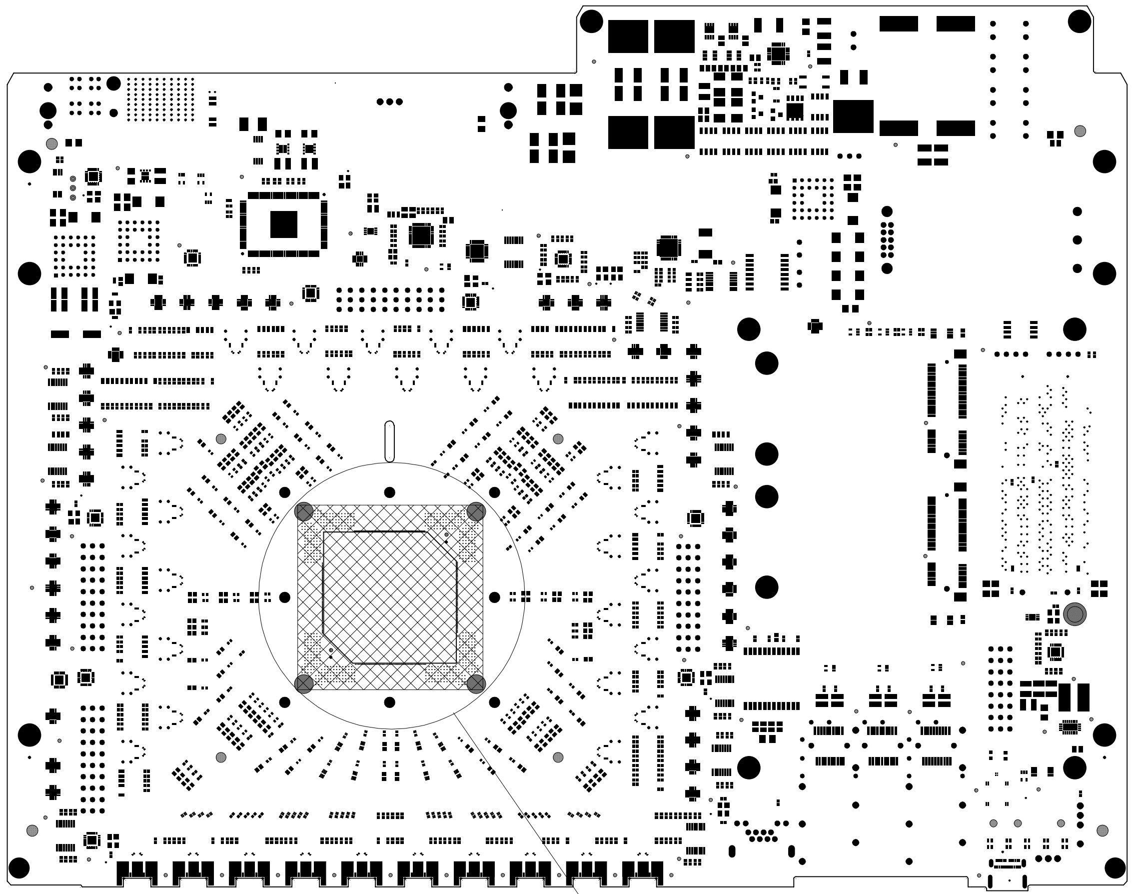


FLATNESS REQUIREMENTS FOR TOP PAD FOOTPRINT AREA

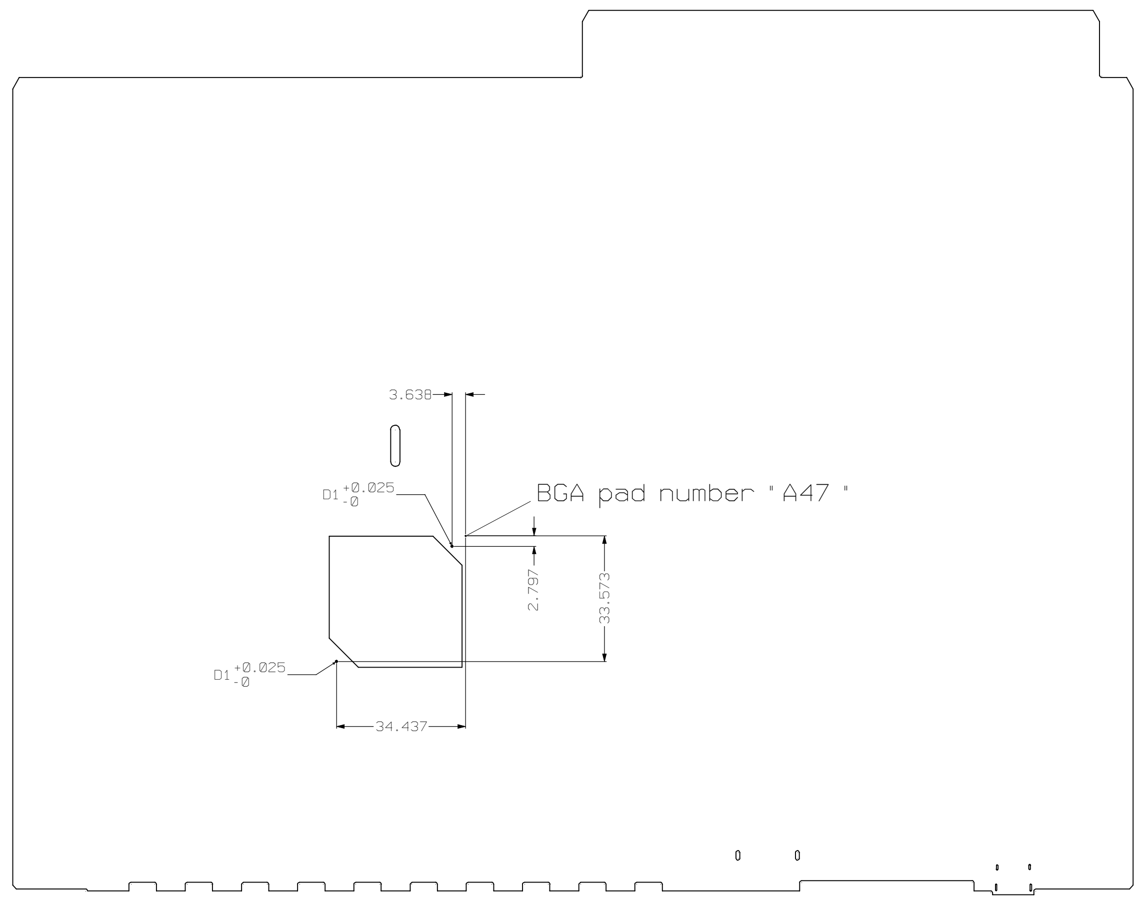
For all the compression contact pads (within the entire module footprint area) indicated in the detail, coplanarity must be <= of 10um (including surface finish) considering copper thickness and the Bow&twist of the board.
This is the maximum misplanarities that can be absorbed during compression-mount phase

Y
0 X

(COMPONENT VIEW)

THIS PCB MUST COMPLY WITH ALL APPLICABLE REQUIREMENTS INDICATED IN PA.00809

Units : Millimeters	Pcb P/N P12866-01	Assembly P/N : C61024	System P/N : SMO	Not to Scale
Description : PASSION-MOD1	Issued by : Crippf	Approved by : Cesane	Date : 18-09-2020	Page : 5-7
	smoptics siae microelettronica group		Document ID : DRP. P12866-01	Revision 01



REGISTRATION TOOLING HOLES

NOTE 1: N.2 Registration tooling holes at diagonally opposite cavity corners

NOTE 2: These holes shall be drilled when outer layers have been etched with their final pattern

NOTE 3: Coordinates origin location is BGA pad 'A47' (reference point)

NOTE 4: holes diameter are 1 mm -0/+0.025 mm not plated

NOTE 5: Tolerance for all dimension respect the reference point (pad 'A47') Must be +/-0.025mm or better (Holes Positional Tolerance)

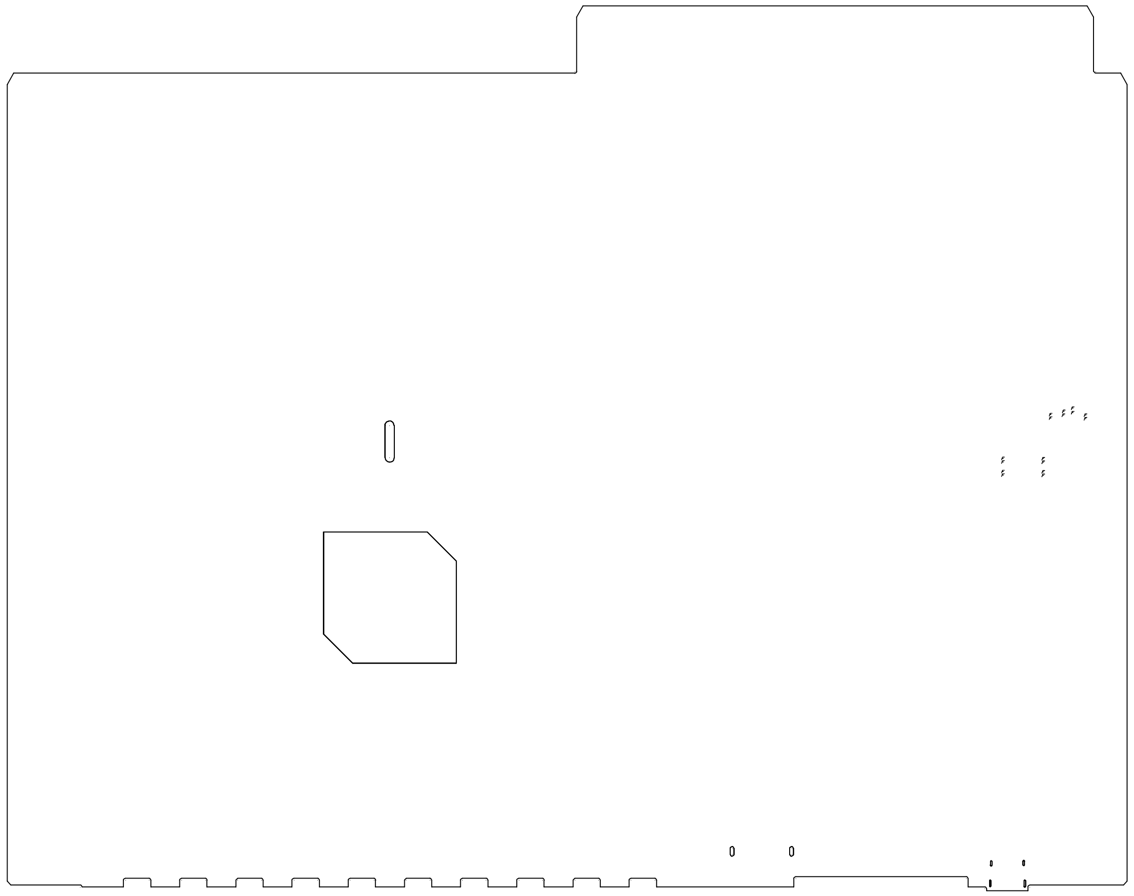
Through Holes				
Symbol	Diameter	Plated	Quantity	Tollerance
N	1.00	NO	2	+0.025 -0

Y
Ø X

(COMPONENT VIEW)

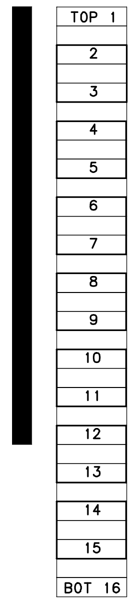
THIS PCB MUST COMPLY WITH ALL APPLICABLE REQUIREMENTS INDICATED IN PA.00809

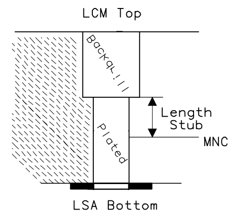
Units : Millimeters	Pcb P/N P12866-01	Assembly P/N : C61024	System P/N : SMO	Not to Scale
Description : PASSION-MOD1	Issued by : Crippf	Approved by : Cesane	Date : 18-09-2020	Page : 6-7
Property of SMOptics all rights reserved	smoptics siae microelettronica group		Document ID : DRP. P12866-01	Revision 01



BACKDRILL LEVEL from layer 1 to layer 12

DRILLING INDICATIONS FOR BACK_DRILL								
BACKDRILL LEVELS	SYMBOL	HOLE PIN DIAMETER	TOOL	HOLE BKD DIAMETER	HOLES QUANTITY	MUST NO CUT (MNC)	STUB LENGHT	STUB LENGHT TOLLERANCE
BACKDRILL 1-12	F	0.20 mm	Bkd_1_12	0.40 mm	16	Layer 12	0.152 mm	+/-0.1 mm





Pad on LCM Top side must be removed

(COMPONENT VIEW)

THIS PCB MUST COMPLY WITH ALL APPLICABLE REQUIREMENTS INDICATED IN PA.00809

Units : Millimeters	Pcb P/N P12866-01	Assembly P/N : C61024	System P/N : SMO	Not to Scale	
Description : PASSION-MOD1		Issued by : Crippf	Approved by : Cesane	Date : 18-09-2020	Page : 7-7
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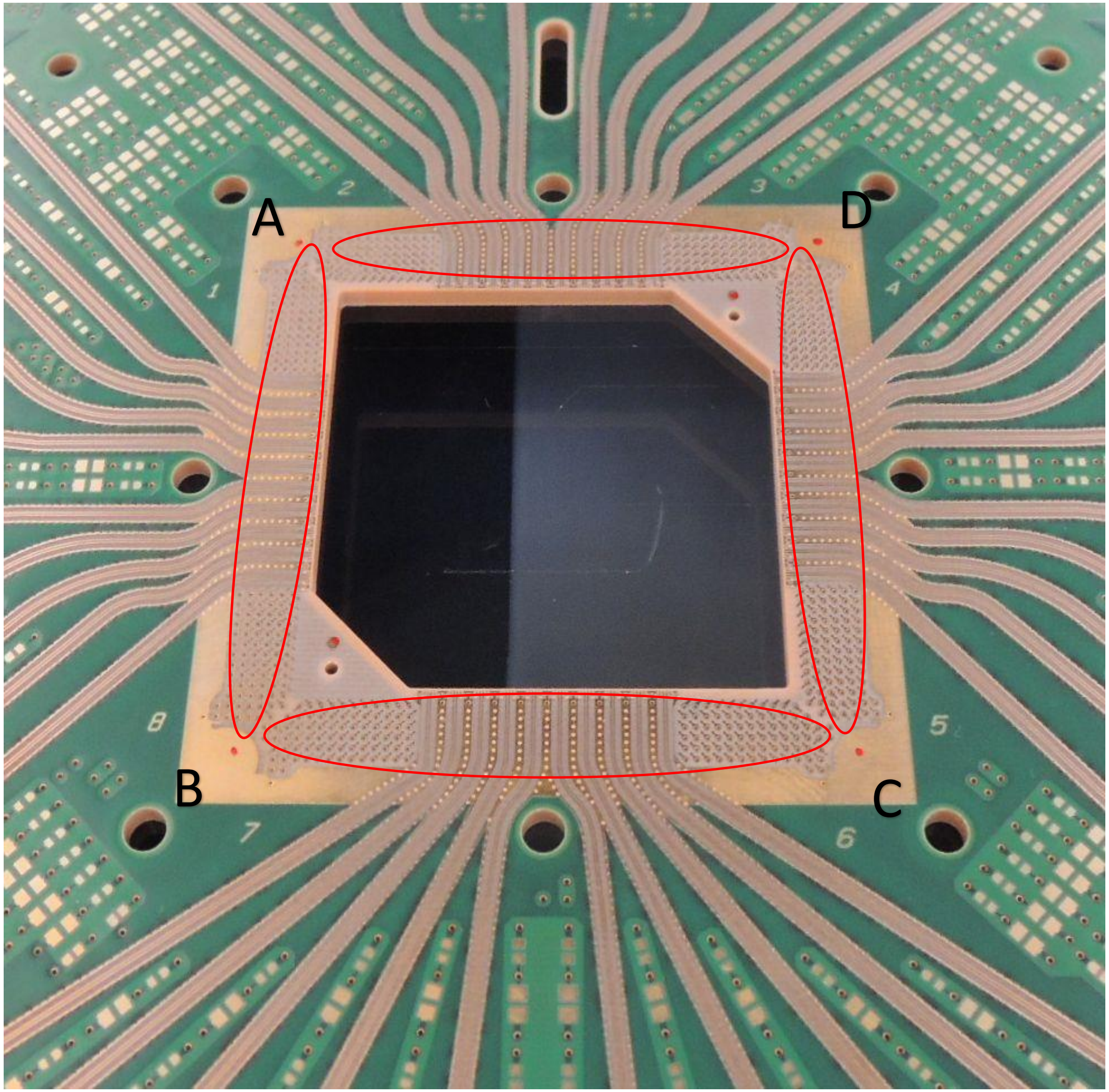
Misure Planarità PCB   D60257 Passion (OGP Flash 400)



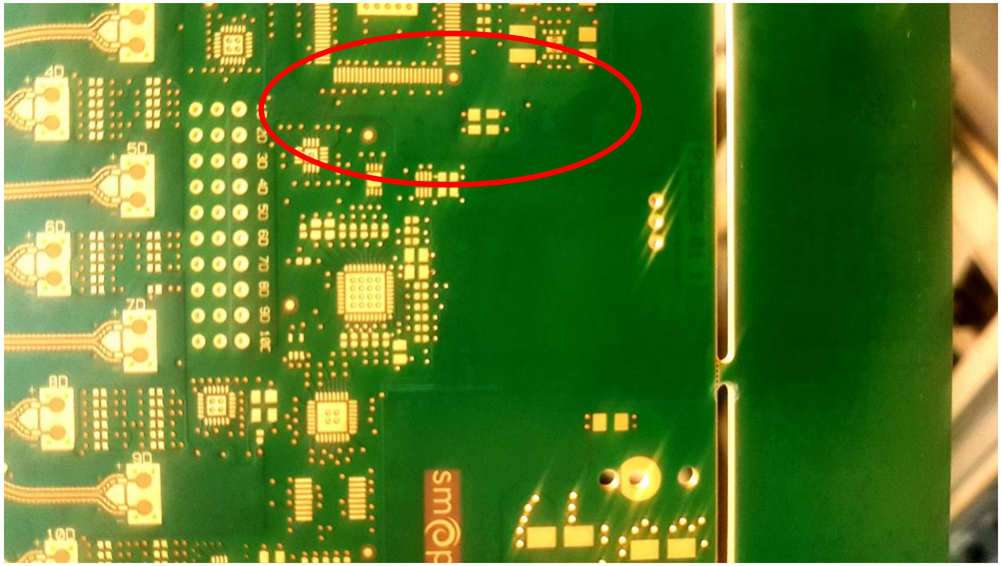
Presi 4 punti A,B,C e D su finitura, viene costruito il piano di riferimento con valore planarità =0 (Z=0).
Successivamente vengono presi 16 punti all'interno delle zone cerchiate in rosso (4 per zona) ed eseguite le misure di altezza tramite auto focus della zeta OGP Flash tra tutti i punti.
Il valore di planarità nominale è stata definito considerando i **10 micron** imposti (compreso la finitura – immersion gold), più la tolleranza macchina.
Il valore di scostamento indicato in fase di taratura OGP per misure in zeta, è **5,6** micron con scostamenti di X e Y = 0, quindi condizioni ideali che porterebbero ad un valore di planarità Max **15,6** micron.

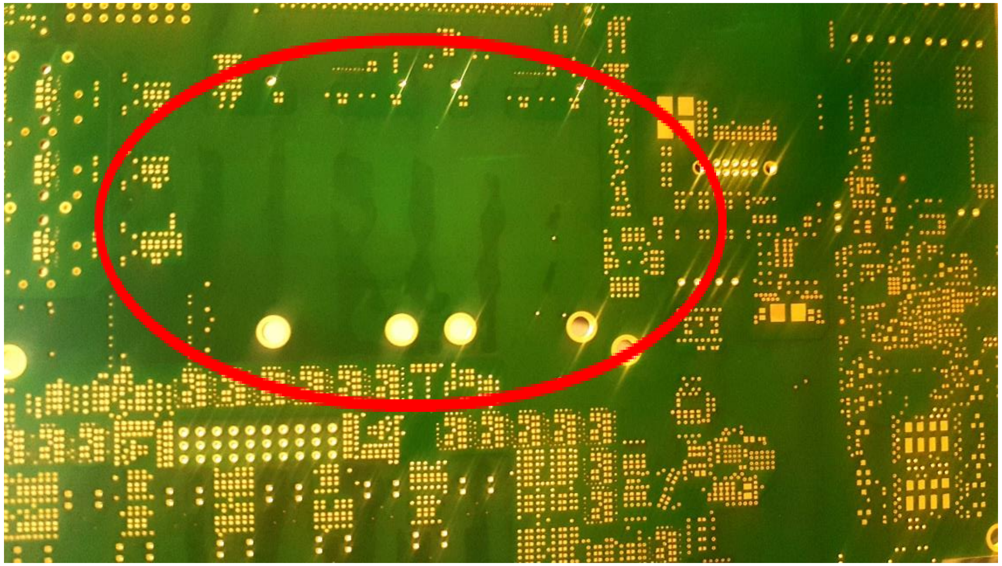
I valori di planarità misurati sui 5 PCB sono:

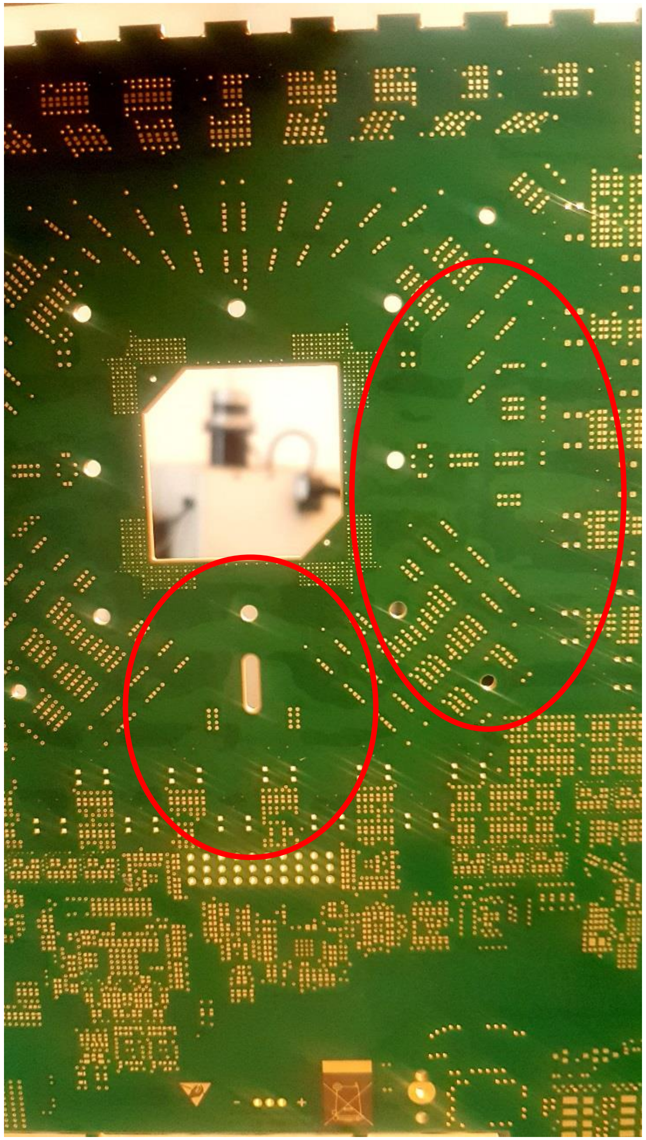
PCB N°1= **9** micron
PCB N°2 =**21** micron
PCB N°3 =**12** micron
PCB N°4 =**15** micron
PCB N°5 =**14** micron
Nei report allegati, le misure di ogni singolo PCB e di ogni singolo punto.

Nota:
Il PCB N°2 e N°5, presentano delle chiazze nel multistrato che indicano un PCB potenzialmente delaminato (vedi pag.2).

Misure Planarità PCB   D60257 Passion (OGP Flash 400)







```
========================================================================
Intestazione:
------------------------------------------------------------------------
Setup:
========================================================================
Blocco 1     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Piano       Best Fit
   p r s e                       Rilevato    Nominale Superiore Inferiore
             Inclinazione          +0.048      +0.035    +0.000    -0.000

   p r s e                       Rilevato  Tolleranza    Mod       DI/DE
             Planarita'            +0.007      +0.000
             Profilo +             +0.004      +0.000    -/+
             Profilo -             -0.004      +0.000    -/+

Punti   : 4          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +196.350     +76.768      +2.100    7.274  191  250   33    0          Focus  *
    +196.352    +127.679      +2.050    7.274  191  250   33    0          Focus  *
    +146.182    +127.679      +2.056    7.274  191  250   33    0          Focus  *
    +146.180     +76.774      +2.093    7.274  191  250   33    0          Focus  *
------------------------------------------------------------------------
Blocco 2     MM        Cartes.   Gradi Decimali    Costruito
Comment:

Prompt:

 Level
      Da Rilevato
      Level XY


     1
------------------------------------------------------------------------
Blocco 3     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                       Rilevato    Nominale Superiore Inferiore
             Coordinata X        +152.344    +152.358    +0.000    -0.000
             Coordinata Y         +78.633     +78.603    +0.000    -0.000
             Coordinata Z          -0.006      -0.008    +0.000    -0.000

   p r s e                       Rilevato  Tolleranza    Mod       DI/DE
             Posizion              +0.066      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +152.343     +78.633      -0.006    7.274  191  250   33    0          Focus  *
------------------------------------------------------------------------
```

```
Blocco 4     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                     Rilevato    Nominale Superiore Inferiore
             Coordinata X       +157.143    +157.155    +0.000    -0.000
             Coordinata Y        +79.420     +79.393    +0.000    -0.000
             Coordinata Z         -0.005      -0.014    +0.000    -0.000

   p r s e                     Rilevato  Tolleranza    Mod       DI/DE
             Posizion             +0.058      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +157.143     +79.420      -0.004    7.274  191  250   33    0          Focus  *
-------------------------------------------------------------------------
Blocco 5     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                     Rilevato    Nominale Superiore Inferiore
             Coordinata X       +149.785    +149.801    +0.000    -0.000
             Coordinata Y        +82.891     +82.861    +0.000    -0.000
             Coordinata Z         -0.004      -0.011    +0.000    -0.000

   p r s e                     Rilevato  Tolleranza    Mod       DI/DE
             Posizion             +0.067      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +149.785     +82.891      -0.004    7.274  191  250   33    0          Focus  *
-------------------------------------------------------------------------
Blocco 6     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                     Rilevato    Nominale Superiore Inferiore
             Coordinata X       +153.933    +153.966    +0.000    -0.000
             Coordinata Y        +83.425     +83.406    +0.000    -0.000
             Coordinata Z         -0.007      -0.013    +0.000    -0.000

   p r s e                     Rilevato  Tolleranza    Mod       DI/DE
             Posizion             +0.076      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +153.932     +83.426      -0.005    7.274  191  250   33    0          Focus  *
-------------------------------------------------------------------------
Blocco 7     MM        Cartes.   Gradi Decimali    Misura
```

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+189.752	+189.801	+0.000	-0.000
	Coordinata Y	+86.281	+86.241	+0.000	-0.000
	Coordinata Z	-0.004	-0.021	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.126	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+189.752	+86.282	-0.003	7.274	191	250	33	0	Focus	*

Blocco 8 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+191.346	+191.384	+0.000	-0.000
	Coordinata Y	+81.010	+80.967	+0.000	-0.000
	Coordinata Z	+0.000	-0.026	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.116	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+191.346	+81.010	+0.001	7.274	191	250	33	0	Focus	*

Blocco 9 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+185.774	+185.795	+0.000	-0.000
	Coordinata Y	+82.600	+82.558	+0.000	-0.000
	Coordinata Z	-0.002	-0.022	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.094	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+185.774	+82.601	-0.002	7.274	191	250	33	0	Focus	*

Blocco 10 MM Cartes. Gradi Decimali Misura
Comment:

```
Prompt:

 Punto
   p r s e                    Rilevato    Nominale Superiore Inferiore
             Coordinata X      +183.366    +183.403    +0.000    -0.000
             Coordinata Y       +79.403     +79.362    +0.000    -0.000
             Coordinata Z        -0.002      -0.021    +0.000    -0.000

   p r s e                    Rilevato  Tolleranza    Mod       DI/DE
             Posizion            +0.111      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +183.366     +79.403      -0.003    7.274  191  250   33    0          Focus  *
-------------------------------------------------------------------------
Blocco 11    MM       Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                    Rilevato    Nominale Superiore Inferiore
             Coordinata X      +190.395    +190.419    +0.000    -0.000
             Coordinata Y      +125.540    +125.511    +0.000    -0.000
             Coordinata Z        -0.009      +0.000    +0.000    -0.000

   p r s e                    Rilevato  Tolleranza    Mod       DI/DE
             Posizion            +0.076      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +190.395    +125.541      -0.008    7.274  191  250   33    0          Focus  *
-------------------------------------------------------------------------
Blocco 12    MM       Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                    Rilevato    Nominale Superiore Inferiore
             Coordinata X      +192.202    +192.226    +0.000    -0.000
             Coordinata Y      +121.314    +121.271    +0.000    -0.000
             Coordinata Z        -0.010      -0.005    +0.000    -0.000

   p r s e                    Rilevato  Tolleranza    Mod       DI/DE
             Posizion            +0.099      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +192.202    +121.315      -0.010    7.274  191  250   33    0          Focus  *
-------------------------------------------------------------------------
Blocco 13    MM       Cartes.   Gradi Decimali    Misura
Comment:
```

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+184.792	+184.817	+0.000	-0.000
	Coordinata Y	+122.352	+122.313	+0.000	-0.000
	Coordinata Z	-0.011	-0.012	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.091	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+184.792	+122.352	-0.012	7.274	191	250	33	0	Focus	*

Blocco 14 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+180.777	+180.824	+0.000	-0.000
	Coordinata Y	+124.748	+124.726	+0.000	-0.000
	Coordinata Z	-0.005	-0.004	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.104	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+180.778	+124.749	-0.006	7.274	191	250	33	0	Focus	*

Blocco 15 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+151.360	+151.393	+0.000	-0.000
	Coordinata Y	+124.771	+124.750	+0.000	-0.000
	Coordinata Z	-0.004	-0.015	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.078	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+151.360	+124.772	-0.005	7.274	191	250	33	0	Focus	*

Blocco 16 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+161.749	+161.786	+0.000	-0.000
	Coordinata Y	+124.779	+124.744	+0.000	-0.000
	Coordinata Z	-0.002	-0.011	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.101	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+161.749	+124.778	-0.003	7.274	191	250	33	0	Focus	*

Blocco 17 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+155.351	+155.392	+0.000	-0.000
	Coordinata Y	+120.784	+120.744	+0.000	-0.000
	Coordinata Z	-0.005	-0.016	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.115	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+155.351	+120.784	-0.005	7.274	191	250	33	0	Focus	*

Blocco 18 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+151.407	+151.434	+0.000	-0.000
	Coordinata Y	+120.317	+120.289	+0.000	-0.000
	Coordinata Z	-0.007	-0.018	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.077	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+151.408	+120.317	-0.008	7.274	191	250	33	0	Focus	*

Blocco 19 MM Cartes. Gradi Decimali Costruito

Comment:

Planarità

Prompt:

Piano Best Fit

p r s e		Rilevato	Nominale	Superiore	Inferiore
■	Inclinazione	+0.004	+0.000	+0.009	-0.009

p r s e		Rilevato	Tolleranza	Mod	DI/DE
■ v	Planarita'	+0.009	+0.018		
	Profilo +	+0.005	+0.000	-/+	
	Profilo -	-0.005	+0.000	-/+	

No. Elementi: 16 Composite: No

17, 18, 16, 14, 15, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3

Pie' di pagina:

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Intestazione:

Setup:

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Blocco 1 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Piano Best Fit

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Inclinazione	+0.071	+0.035	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Planarita'	+0.015	+0.000		
	Profilo +	+0.007	+0.000	-/+	
	Profilo -	-0.007	+0.000	-/+	

Punti : 4 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+196.350	+76.768	+2.100	7.274	191	250	33	0	Focus	*
+196.352	+127.679	+2.050	7.274	191	250	33	0	Focus	*
+146.182	+127.679	+2.056	7.274	191	250	33	0	Focus	*
+146.180	+76.774	+2.093	7.274	191	250	33	0	Focus	*

Blocco 2 MM Cartes. Gradi Decimali Costruito

Comment:

Prompt:

Level

Da Rilevato

Level XY

1

Blocco 3 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+152.343	+152.358	+0.000	-0.000
	Coordinata Y	+78.632	+78.603	+0.000	-0.000
	Coordinata Z	+0.003	-0.008	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.066	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+152.343	+78.633	-0.006	7.274	191	250	33	0	Focus	*

```
Blocco 4     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                        Rilevato    Nominale Superiore Inferiore
             Coordinata X        +157.143    +157.155    +0.000    -0.000
             Coordinata Y         +79.420     +79.393    +0.000    -0.000
             Coordinata Z          +0.007      -0.014    +0.000    -0.000

   p r s e                        Rilevato  Tolleranza    Mod       DI/DE
             Posizion              +0.059      +0.000    RFS

Punti   : 1           Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +157.143     +79.420      -0.004    7.274  191  250   33    0          Focus  *
------------------------------------------------------------------------
Blocco 5     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                        Rilevato    Nominale Superiore Inferiore
             Coordinata X        +149.784    +149.801    +0.000    -0.000
             Coordinata Y         +82.891     +82.861    +0.000    -0.000
             Coordinata Z          +0.004      -0.011    +0.000    -0.000

   p r s e                        Rilevato  Tolleranza    Mod       DI/DE
             Posizion              +0.068      +0.000    RFS

Punti   : 1           Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +149.785     +82.891      -0.004    7.274  191  250   33    0          Focus  *
------------------------------------------------------------------------
Blocco 6     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                        Rilevato    Nominale Superiore Inferiore
             Coordinata X        +153.932    +153.966    +0.000    -0.000
             Coordinata Y         +83.425     +83.406    +0.000    -0.000
             Coordinata Z          +0.008      -0.013    +0.000    -0.000

   p r s e                        Rilevato  Tolleranza    Mod       DI/DE
             Posizion              +0.079      +0.000    RFS

Punti   : 1           Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +153.932     +83.426      -0.005    7.274  191  250   33    0          Focus  *
------------------------------------------------------------------------
Blocco 7     MM        Cartes.   Gradi Decimali    Misura
```

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+189.751	+189.801	+0.000	-0.000
	Coordinata Y	+86.281	+86.241	+0.000	-0.000
	Coordinata Z	-0.008	-0.021	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.127	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+189.752	+86.282	-0.003	7.274	191	250	33	0	Focus	*

Blocco 8 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+191.346	+191.384	+0.000	-0.000
	Coordinata Y	+81.010	+80.967	+0.000	-0.000
	Coordinata Z	-0.013	-0.026	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.116	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+191.346	+81.010	+0.001	7.274	191	250	33	0	Focus	*

Blocco 9 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+185.773	+185.795	+0.000	-0.000
	Coordinata Y	+82.600	+82.558	+0.000	-0.000
	Coordinata Z	-0.006	-0.022	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.095	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+185.774	+82.601	-0.002	7.274	191	250	33	0	Focus	*

Blocco 10 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+183.366	+183.403	+0.000	-0.000
	Coordinata Y	+79.403	+79.362	+0.000	-0.000
	Coordinata Z	-0.004	-0.021	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.111	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+183.366	+79.403	-0.003	7.274	191	250	33	0	Focus	*

Blocco 11 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+190.395	+190.419	+0.000	-0.000
	Coordinata Y	+125.541	+125.511	+0.000	-0.000
	Coordinata Z	+0.003	+0.000	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.077	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+190.395	+125.541	-0.008	7.274	191	250	33	0	Focus	*

Blocco 12 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+192.202	+192.226	+0.000	-0.000
	Coordinata Y	+121.315	+121.271	+0.000	-0.000
	Coordinata Z	-0.002	-0.005	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.101	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+192.202	+121.315	-0.010	7.274	191	250	33	0	Focus	*

Blocco 13 MM Cartes. Gradi Decimali Misura
Comment:

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Prompt:

 Punto
   p r s e                      Rilevato    Nominale Superiore Inferiore
            Coordinata X        +184.792    +184.817    +0.000    -0.000
            Coordinata Y        +122.352    +122.313    +0.000    -0.000
            Coordinata Z          +0.002      -0.012    +0.000    -0.000

   p r s e                      Rilevato  Tolleranza    Mod       DI/DE
            Posizion              +0.092      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +184.792    +122.352      -0.012    7.274  191  250   33    0         Focus  *
-------------------------------------------------------------------------
Blocco 14    MM       Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                      Rilevato    Nominale Superiore Inferiore
            Coordinata X        +180.777    +180.824    +0.000    -0.000
            Coordinata Y        +124.748    +124.726    +0.000    -0.000
            Coordinata Z          +0.011      -0.004    +0.000    -0.000

   p r s e                      Rilevato  Tolleranza    Mod       DI/DE
            Posizion              +0.104      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +180.778    +124.749      -0.006    7.274  191  250   33    0         Focus  *
-------------------------------------------------------------------------
Blocco 15    MM       Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                      Rilevato    Nominale Superiore Inferiore
            Coordinata X        +151.360    +151.393    +0.000    -0.000
            Coordinata Y        +124.771    +124.750    +0.000    -0.000
            Coordinata Z          -0.005      -0.015    +0.000    -0.000

   p r s e                      Rilevato  Tolleranza    Mod       DI/DE
            Posizion              +0.079      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +151.360    +124.772      -0.005    7.274  191  250   33    0         Focus  *
-------------------------------------------------------------------------
Blocco 16    MM       Cartes.   Gradi Decimali    Misura
Comment:

Prompt:
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Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+161.748	+161.786	+0.000	-0.000
	Coordinata Y	+124.779	+124.744	+0.000	-0.000
	Coordinata Z	+0.011	-0.011	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.102	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+161.749	+124.778	-0.003	7.274	191	250	33	0		Focus *

Blocco 17 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+155.351	+155.392	+0.000	-0.000
	Coordinata Y	+120.784	+120.744	+0.000	-0.000
	Coordinata Z	+0.004	-0.016	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.116	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+155.351	+120.784	-0.005	7.274	191	250	33	0		Focus *

Blocco 18 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+151.407	+151.434	+0.000	-0.000
	Coordinata Y	+120.317	+120.289	+0.000	-0.000
	Coordinata Z	-0.005	-0.018	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.077	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+151.408	+120.317	-0.008	7.274	191	250	33	0		Focus *

Blocco 19 MM Cartes. Gradi Decimali Costruito

Comment:

Planarità

Prompt:

Piano Best Fit

p r s e		Rilevato	Nominale	Superiore	Inferiore
■	Inclinazione	+0.011	+0.000	+0.009	-0.009

p r s e		Rilevato	Tolleranza	Mod	DI/DE
■ v	Planarita'	+0.021	+0.018		
	Profilo +	+0.011	+0.000	-/+	
	Profilo -	-0.010	+0.000	-/+	

No. Elementi: 16 Composite: No
17, 18, 16, 14, 15, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3

Pie' di pagina:

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========================================================================
Intestazione:
------------------------------------------------------------------------
Setup:
========================================================================
Blocco 1     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Piano       Best Fit
   p r s e                    Rilevato    Nominale Superiore Inferiore
             Inclinazione       +0.040      +0.035    +0.000    -0.000

   p r s e                    Rilevato  Tolleranza    Mod       DI/DE
             Planarita'         +0.003      +0.000
             Profilo +          +0.002      +0.000    -/+
             Profilo -          -0.002      +0.000    -/+

Punti   : 4          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +196.350     +76.768      +2.100    7.274  191  250   33    0          Focus  *
    +196.352    +127.679      +2.050    7.274  191  250   33    0          Focus  *
    +146.182    +127.679      +2.056    7.274  191  250   33    0          Focus  *
    +146.180     +76.774      +2.093    7.274  191  250   33    0          Focus  *
------------------------------------------------------------------------
Blocco 2     MM        Cartes.   Gradi Decimali    Costruito
Comment:

Prompt:

 Level
      Da Rilevato
      Level XY


     1
------------------------------------------------------------------------
Blocco 3     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                    Rilevato    Nominale Superiore Inferiore
             Coordinata X     +152.343    +152.358    +0.000    -0.000
             Coordinata Y      +78.633     +78.603    +0.000    -0.000
             Coordinata Z       -0.003      -0.008    +0.000    -0.000

   p r s e                    Rilevato  Tolleranza    Mod       DI/DE
             Posizion           +0.067      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +152.343     +78.633      -0.006    7.274  191  250   33    0          Focus  *
------------------------------------------------------------------------
```

Blocco 4 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+157.143	+157.155	+0.000	-0.000
	Coordinata Y	+79.419	+79.393	+0.000	-0.000
	Coordinata Z	+0.001	-0.014	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.058	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+157.143	+79.420	-0.004	7.274	191	250	33	0	Focus	*

Blocco 5 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+149.784	+149.801	+0.000	-0.000
	Coordinata Y	+82.891	+82.861	+0.000	-0.000
	Coordinata Z	-0.003	-0.011	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.068	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+149.785	+82.891	-0.004	7.274	191	250	33	0	Focus	*

Blocco 6 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+153.933	+153.966	+0.000	-0.000
	Coordinata Y	+83.425	+83.406	+0.000	-0.000
	Coordinata Z	+0.002	-0.013	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.077	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+153.932	+83.426	-0.005	7.274	191	250	33	0	Focus	*

Blocco 7 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+189.752	+189.801	+0.000	-0.000
	Coordinata Y	+86.281	+86.241	+0.000	-0.000
	Coordinata Z	+0.008	-0.021	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.126	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.	
+189.752	+86.282	-0.003	7.274	191	250	33	0		Focus	*

Blocco 8 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+191.346	+191.384	+0.000	-0.000
	Coordinata Y	+81.010	+80.967	+0.000	-0.000
	Coordinata Z	+0.000	-0.026	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.116	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.	
+191.346	+81.010	+0.001	7.274	191	250	33	0		Focus	*

Blocco 9 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+185.773	+185.795	+0.000	-0.000
	Coordinata Y	+82.601	+82.558	+0.000	-0.000
	Coordinata Z	+0.004	-0.022	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.095	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.	
+185.774	+82.601	-0.002	7.274	191	250	33	0		Focus	*

Blocco 10 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+183.366	+183.403	+0.000	-0.000
	Coordinata Y	+79.403	+79.362	+0.000	-0.000
	Coordinata Z	+0.005	-0.021	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.110	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.	
+183.366	+79.403	-0.003	7.274	191	250	33	0		Focus	*

Blocco 11 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+190.394	+190.419	+0.000	-0.000
	Coordinata Y	+125.541	+125.511	+0.000	-0.000
	Coordinata Z	-0.006	+0.000	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.077	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.	
+190.395	+125.541	-0.008	7.274	191	250	33	0		Focus	*

Blocco 12 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+192.202	+192.226	+0.000	-0.000
	Coordinata Y	+121.315	+121.271	+0.000	-0.000
	Coordinata Z	-0.004	-0.005	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.101	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.	
+192.202	+121.315	-0.010	7.274	191	250	33	0		Focus	*

Blocco 13 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+184.792	+184.817	+0.000	-0.000
	Coordinata Y	+122.352	+122.313	+0.000	-0.000
	Coordinata Z	-0.005	-0.012	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.091	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+184.792	+122.352	-0.012	7.274	191	250	33	0	Focus	*

Blocco 14 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+180.777	+180.824	+0.000	-0.000
	Coordinata Y	+124.749	+124.726	+0.000	-0.000
	Coordinata Z	+0.000	-0.004	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.104	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+180.778	+124.749	-0.006	7.274	191	250	33	0	Focus	*

Blocco 15 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+151.360	+151.393	+0.000	-0.000
	Coordinata Y	+124.772	+124.750	+0.000	-0.000
	Coordinata Z	+0.002	-0.015	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.079	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+151.360	+124.772	-0.005	7.274	191	250	33	0	Focus	*

Blocco 16 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+161.749	+161.786	+0.000	-0.000
	Coordinata Y	+124.779	+124.744	+0.000	-0.000
	Coordinata Z	+0.006	-0.011	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.102	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+161.749	+124.778	-0.003	7.274	191	250	33	0	Focus	*

Blocco 17 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+155.351	+155.392	+0.000	-0.000
	Coordinata Y	+120.784	+120.744	+0.000	-0.000
	Coordinata Z	+0.004	-0.016	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.116	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+155.351	+120.784	-0.005	7.274	191	250	33	0	Focus	*

Blocco 18 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+151.408	+151.434	+0.000	-0.000
	Coordinata Y	+120.317	+120.289	+0.000	-0.000
	Coordinata Z	-0.001	-0.018	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.077	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+151.408	+120.317	-0.008	7.274	191	250	33	0	Focus	*

Blocco 19 MM Cartes. Gradi Decimali Costruito

Comment:

Planarità

Prompt:

Piano Best Fit

p r s e		Rilevato	Nominale	Superiore	Inferiore
■	Inclinazione	+0.002	+0.000	+0.009	-0.009

p r s e		Rilevato	Tolleranza	Mod	DI/DE
■ v	Planarita'	+0.012	+0.018		
	Profilo +	+0.005	+0.000	-/+	
	Profilo -	-0.007	+0.000	-/+	

No. Elementi: 16 Composite: No
17, 18, 16, 14, 15, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3

Pie' di pagina:

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==========================================================================
Intestazione:
--------------------------------------------------------------------------
Setup:
==========================================================================
Blocco 1     MM       Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Piano       Best Fit
   p r s e                        Rilevato    Nominale Superiore Inferiore
             Inclinazione           +0.090      +0.035    +0.000    -0.000

   p r s e                        Rilevato  Tolleranza    Mod       DI/DE
             Planarita'             +0.001      +0.000
             Profilo +              +0.001      +0.000    -/+
             Profilo -              -0.001      +0.000    -/+

Punti   : 4          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +196.350     +76.768      +2.100    7.274  191  250   33    0         Focus  *
    +196.352    +127.679      +2.050    7.274  191  250   33    0         Focus  *
    +146.182    +127.679      +2.056    7.274  191  250   33    0         Focus  *
    +146.180     +76.774      +2.093    7.274  191  250   33    0         Focus  *
--------------------------------------------------------------------------
Blocco 2     MM       Cartes.   Gradi Decimali    Costruito
Comment:

Prompt:

 Level
      Da Rilevato
      Level XY


     1
--------------------------------------------------------------------------
Blocco 3     MM       Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                        Rilevato    Nominale Superiore Inferiore
             Coordinata X         +152.343    +152.358    +0.000    -0.000
             Coordinata Y          +78.632     +78.603    +0.000    -0.000
             Coordinata Z           -0.005      -0.008    +0.000    -0.000

   p r s e                        Rilevato  Tolleranza    Mod       DI/DE
             Posizion               +0.066      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +152.343     +78.633      -0.006    7.274  191  250   33    0         Focus  *
--------------------------------------------------------------------------
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Blocco 4 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+157.143	+157.155	+0.000	-0.000
	Coordinata Y	+79.419	+79.393	+0.000	-0.000
	Coordinata Z	-0.004	-0.014	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.058	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+157.143	+79.420	-0.004	7.274	191	250	33	0	Focus	*

Blocco 5 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+149.785	+149.801	+0.000	-0.000
	Coordinata Y	+82.890	+82.861	+0.000	-0.000
	Coordinata Z	-0.005	-0.011	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.067	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+149.785	+82.891	-0.004	7.274	191	250	33	0	Focus	*

Blocco 6 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+153.932	+153.966	+0.000	-0.000
	Coordinata Y	+83.425	+83.406	+0.000	-0.000
	Coordinata Z	-0.006	-0.013	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.078	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+153.932	+83.426	-0.005	7.274	191	250	33	0	Focus	*

Blocco 7 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+189.752	+189.801	+0.000	-0.000
	Coordinata Y	+86.282	+86.241	+0.000	-0.000
	Coordinata Z	+0.007	-0.021	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.127	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+189.752	+86.282	-0.003	7.274	191	250	33	0	Focus	*

Blocco 8 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+191.346	+191.384	+0.000	-0.000
	Coordinata Y	+81.010	+80.967	+0.000	-0.000
	Coordinata Z	+0.003	-0.026	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.116	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+191.346	+81.010	+0.001	7.274	191	250	33	0	Focus	*

Blocco 9 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+185.773	+185.795	+0.000	-0.000
	Coordinata Y	+82.600	+82.558	+0.000	-0.000
	Coordinata Z	+0.006	-0.022	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.094	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+185.774	+82.601	-0.002	7.274	191	250	33	0	Focus	*

Blocco 10 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+183.366	+183.403	+0.000	-0.000
	Coordinata Y	+79.403	+79.362	+0.000	-0.000
	Coordinata Z	+0.006	-0.021	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.111	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+183.366	+79.403	-0.003	7.274	191	250	33	0	Focus	*

Blocco 11 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+190.395	+190.419	+0.000	-0.000
	Coordinata Y	+125.541	+125.511	+0.000	-0.000
	Coordinata Z	-0.001	+0.000	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.077	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+190.395	+125.541	-0.008	7.274	191	250	33	0	Focus	*

Blocco 12 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+192.201	+192.226	+0.000	-0.000
	Coordinata Y	+121.315	+121.271	+0.000	-0.000
	Coordinata Z	+0.000	-0.005	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.101	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+192.202	+121.315	-0.010	7.274	191	250	33	0	Focus	*

Blocco 13 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+184.792	+184.817	+0.000	-0.000
	Coordinata Y	+122.352	+122.313	+0.000	-0.000
	Coordinata Z	-0.003	-0.012	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.092	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+184.792	+122.352	-0.012	7.274	191	250	33	0	Focus	*

Blocco 14 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+180.778	+180.824	+0.000	-0.000
	Coordinata Y	+124.748	+124.726	+0.000	-0.000
	Coordinata Z	+0.008	-0.004	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.104	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+180.778	+124.749	-0.006	7.274	191	250	33	0	Focus	*

Blocco 15 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+151.360	+151.393	+0.000	-0.000
	Coordinata Y	+124.772	+124.750	+0.000	-0.000
	Coordinata Z	+0.002	-0.015	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.079	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+151.360	+124.772	-0.005	7.274	191	250	33	0	Focus	*

Blocco 16 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+161.749	+161.786	+0.000	-0.000
	Coordinata Y	+124.779	+124.744	+0.000	-0.000
	Coordinata Z	+0.009	-0.011	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.102	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+161.749	+124.778	-0.003	7.274	191	250	33	0	Focus	*

Blocco 17 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+155.351	+155.392	+0.000	-0.000
	Coordinata Y	+120.784	+120.744	+0.000	-0.000
	Coordinata Z	+0.001	-0.016	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.116	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+155.351	+120.784	-0.005	7.274	191	250	33	0	Focus	*

Blocco 18 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+151.407	+151.434	+0.000	-0.000
	Coordinata Y	+120.317	+120.289	+0.000	-0.000
	Coordinata Z	-0.002	-0.018	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.078	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+151.408	+120.317	-0.008	7.274	191	250	33	0	Focus	*

Blocco 19 MM Cartes. Gradi Decimali Costruito
Comment:
Planarità
Prompt:

Piano Best Fit

p r s e		Rilevato	Nominale	Superiore	Inferiore
■	Inclinazione	+0.008	+0.000	+0.009	-0.009

p r s e		Rilevato	Tolleranza	Mod	DI/DE
■ v	Planarita'	+0.015	+0.018		
	Profilo +	+0.006	+0.000	-/+	
	Profilo -	-0.008	+0.000	-/+	

No. Elementi: 16 Composite: No

17, 18, 16, 14, 15, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3

Pie' di pagina:

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=========================================================================
Intestazione:
-------------------------------------------------------------------------
Setup:
=========================================================================
Blocco 1     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Piano       Best Fit
   p r s e                      Rilevato    Nominale Superiore Inferiore
             Inclinazione         +0.047      +0.035    +0.000    -0.000

   p r s e                      Rilevato  Tolleranza    Mod       DI/DE
             Planarita'           +0.006      +0.000
             Profilo +            +0.003      +0.000    -/+
             Profilo -            -0.003      +0.000    -/+

Punti   : 4          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +196.350     +76.768      +2.100    7.274  191  250   33    0          Focus  *
    +196.352    +127.679      +2.050    7.274  191  250   33    0          Focus  *
    +146.182    +127.679      +2.056    7.274  191  250   33    0          Focus  *
    +146.180     +76.774      +2.093    7.274  191  250   33    0          Focus  *
-------------------------------------------------------------------------
Blocco 2     MM        Cartes.   Gradi Decimali    Costruito
Comment:

Prompt:

 Level
      Da Rilevato
      Level XY


     1
-------------------------------------------------------------------------
Blocco 3     MM        Cartes.   Gradi Decimali    Misura
Comment:

Prompt:

 Punto
   p r s e                      Rilevato    Nominale Superiore Inferiore
             Coordinata X       +152.343    +152.358    +0.000    -0.000
             Coordinata Y        +78.632     +78.603    +0.000    -0.000
             Coordinata Z         +0.000      -0.008    +0.000    -0.000

   p r s e                      Rilevato  Tolleranza    Mod       DI/DE
             Posizion             +0.066      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +152.343     +78.633      -0.006    7.274  191  250   33    0          Focus  *
-------------------------------------------------------------------------
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Blocco 4 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+157.143	+157.155	+0.000	-0.000
	Coordinata Y	+79.420	+79.393	+0.000	-0.000
	Coordinata Z	+0.004	-0.014	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.059	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+157.143	+79.420	-0.004	7.274	191	250	33	0	Focus	*

Blocco 5 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+149.784	+149.801	+0.000	-0.000
	Coordinata Y	+82.890	+82.861	+0.000	-0.000
	Coordinata Z	-0.003	-0.011	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.067	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+149.785	+82.891	-0.004	7.274	191	250	33	0	Focus	*

Blocco 6 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+153.932	+153.966	+0.000	-0.000
	Coordinata Y	+83.425	+83.406	+0.000	-0.000
	Coordinata Z	+0.002	-0.013	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.079	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+153.932	+83.426	-0.005	7.274	191	250	33	0	Focus	*

Blocco 7 MM Cartes. Gradi Decimali Misura

Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+189.751	+189.801	+0.000	-0.000
	Coordinata Y	+86.281	+86.241	+0.000	-0.000
	Coordinata Z	+0.008	-0.021	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.127	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+189.752	+86.282	-0.003	7.274	191	250	33	0	Focus	*

Blocco 8 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+191.345	+191.384	+0.000	-0.000
	Coordinata Y	+81.010	+80.967	+0.000	-0.000
	Coordinata Z	-0.001	-0.026	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.117	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+191.346	+81.010	+0.001	7.274	191	250	33	0	Focus	*

Blocco 9 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+185.773	+185.795	+0.000	-0.000
	Coordinata Y	+82.601	+82.558	+0.000	-0.000
	Coordinata Z	+0.005	-0.022	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.095	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+185.774	+82.601	-0.002	7.274	191	250	33	0	Focus	*

Blocco 10 MM Cartes. Gradi Decimali Misura
Comment:

```
Prompt:

 Punto
   p r s e                    Rilevato    Nominale Superiore Inferiore
             Coordinata X       +183.366    +183.403    +0.000    -0.000
             Coordinata Y        +79.403     +79.362    +0.000    -0.000
             Coordinata Z         +0.003      -0.021    +0.000    -0.000

   p r s e                    Rilevato  Tolleranza    Mod       DI/DE
             Posizion             +0.111      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +183.366     +79.403      -0.003    7.274  191  250   33    0          Focus  *
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Blocco 11 MM Cartes. Gradi Decimali Misura

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Comment:

Prompt:

 Punto
   p r s e                    Rilevato    Nominale Superiore Inferiore
             Coordinata X       +190.394    +190.419    +0.000    -0.000
             Coordinata Y       +125.541    +125.511    +0.000    -0.000
             Coordinata Z         -0.001      +0.000    +0.000    -0.000

   p r s e                    Rilevato  Tolleranza    Mod       DI/DE
             Posizion             +0.078      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +190.395    +125.541      -0.008    7.274  191  250   33    0          Focus  *
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```

Blocco 12 MM Cartes. Gradi Decimali Misura

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Comment:

Prompt:

 Punto
   p r s e                    Rilevato    Nominale Superiore Inferiore
             Coordinata X       +192.202    +192.226    +0.000    -0.000
             Coordinata Y       +121.315    +121.271    +0.000    -0.000
             Coordinata Z         +0.005      -0.005    +0.000    -0.000

   p r s e                    Rilevato  Tolleranza    Mod       DI/DE
             Posizion             +0.101      +0.000    RFS

Punti   : 1          Stream Dati: No

   Coord. X    Coord. Y    Coord. Z      Zoom Back Ring Aux  SRL   Reticolo Dir.
    +192.202    +121.315      -0.010    7.274  191  250   33    0          Focus  *
--------------------------------------------------------------------------
```

Blocco 13 MM Cartes. Gradi Decimali Misura

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Comment:
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Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+184.792	+184.817	+0.000	-0.000
	Coordinata Y	+122.351	+122.313	+0.000	-0.000
	Coordinata Z	+0.005	-0.012	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.091	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+184.792	+122.352	-0.012	7.274	191	250	33	0	Focus	*

Blocco 14 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+180.777	+180.824	+0.000	-0.000
	Coordinata Y	+124.748	+124.726	+0.000	-0.000
	Coordinata Z	+0.010	-0.004	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.104	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+180.778	+124.749	-0.006	7.274	191	250	33	0	Focus	*

Blocco 15 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+151.360	+151.393	+0.000	-0.000
	Coordinata Y	+124.772	+124.750	+0.000	-0.000
	Coordinata Z	-0.002	-0.015	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.080	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+151.360	+124.772	-0.005	7.274	191	250	33	0	Focus	*

Blocco 16 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+161.748	+161.786	+0.000	-0.000
	Coordinata Y	+124.779	+124.744	+0.000	-0.000
	Coordinata Z	+0.011	-0.011	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.102	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+161.749	+124.778	-0.003	7.274	191	250	33	0	Focus	*

Blocco 17 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+155.351	+155.392	+0.000	-0.000
	Coordinata Y	+120.784	+120.744	+0.000	-0.000
	Coordinata Z	+0.005	-0.016	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.116	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+155.351	+120.784	-0.005	7.274	191	250	33	0	Focus	*

Blocco 18 MM Cartes. Gradi Decimali Misura
Comment:

Prompt:

Punto

p r s e		Rilevato	Nominale	Superiore	Inferiore
	Coordinata X	+151.407	+151.434	+0.000	-0.000
	Coordinata Y	+120.317	+120.289	+0.000	-0.000
	Coordinata Z	+0.002	-0.018	+0.000	-0.000

p r s e		Rilevato	Tolleranza	Mod	DI/DE
	Posizion	+0.078	+0.000	RFS	

Punti : 1 Stream Dati: No

Coord. X	Coord. Y	Coord. Z	Zoom	Back	Ring	Aux	SRL	Reticolo	Dir.
+151.408	+120.317	-0.008	7.274	191	250	33	0	Focus	*

Blocco 19 MM Cartes. Gradi Decimali Costruito
Comment:
Planarità
Prompt:

Piano	Best Fit				
p r s e		Rilevato	Nominale	Superiore	Inferiore
■	Inclinazione	+0.005	+0.000	+0.009	-0.009

p r s e		Rilevato	Tolleranza	Mod	DI/DE
■ v	Planarita'	+0.014	+0.018		
	Profilo +	+0.007	+0.000	-/+	
	Profilo -	-0.007	+0.000	-/+	

No. Elementi: 16   Composite: No

17, 18, 16, 14, 15, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3

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