ZSA: Z80 Standard Architecture

A Proposal for A Z80-based DIY Computer Architecture

By K. Cardoza, G. Sutherland, et. al.

Draft Version 0.6.3

Foreword

Abstract

This proposal will outline the physical, electrical, and software requirements for a community-owned, open-source hardware, 3.3V logic level DIY computer architecture, built around Z80 and compatible CPUs. Inspired by, and physically similar to, the Industry Standard Architecture, or ISA, bus, this bus will serve the same purpose for new, Z80-based DIY computer systems: provide an open standard to which any and all participants are welcome.

Goals

The inspiration and motivation behind this proposal is, simply put, the current reality facing computer hobbyists: 5V parts are becoming harder to find, while 3.3V parts are plentiful, inexpensive, and far more broad in their natures and selection. Moving from a 5V standard logic to 3.3V opens up a new world of potential, enabling the use not only of more modern surface-mount logic and memory and processor devices, but CPLDs, FPGAs, microcontrollers, and specialized ASICs which all default to 3.3V logic levels.

The goal of this proposal is to design and implement a 3.3V standard for DIY computer kits and accessories, one which will enable the use of all the above components, and many more than can be enumerated here, as well as enable the use of modern, high-quality, economical PCB fabrication and population facilities provided to the modern hobbyist by such services as PCBWAY and JLCPCB, among others.

Such a standard will also enable small businesses and craftspeople, such as might be found among the sellers on Tindie, to build original products for a common platform.

Definitions

The terms listed here are to be interpreted with the following definitions:

1. “The standard” refers to this document.
2. “Backplane” means a PCB with female edge connector slots meant to provide power and signal connections to expansion cards.

3. “Expansion card” means a PCB which is designed to connect to the ZSA bus using the 72-pin edge connector.
4. “Implementation” means a physical product or design meant to be used under this standard.
5. “MUST” means that an implementation is not compliant if it does not meet the listed requirement.
6. “MUST NOT” means that an implemention is not compliant if it does what is listed in the rule.
7. “Conforming implementation” means an implementation which meets all “MUST” and “MUST NOT” requirements in this standard, and is thus entitled to carry the conformance marks and advertise its conformance to the standard.
8. “Coforming backplane” means a backplane which is a conforming implementation.
9. “Conforming expansion card” means an expansion card which is a conforming implementation.
10. “Conforming system” means a collection of one or more conforming impelemntations which collectively implement a usable computer system compliant with this standard.
11. “MAY” means that an implementation’s compliance status is neither confirmed nor denied by the inclusion or absence of the designated attribute(s).
12. “SHOULD” means the same as “MAY”, with the addtion that the adherence to the rule is strongly advised.
13. “EITHER” means that a requirment is met for a “MAY” or “MUST” rule in one of two ways, separated by an “OR”.
14. “Implementation defined” means that the specific methods and designs needed to meet a requirement are left to the designer of the conforming implementation to determine.
15. “Z80 CPU” means a processor, or emulation of a processor[1], which is logically and electrically compatible with the ZSA bus and executes Z80 opcodes.
16. The “rear” edge of an expansion card is the edge which has the Keystone mounting holes.
17. The “front” edge of an expansion card is the edge directly opposite the rear edge.
18. The “top” edge of an expansion card is the edge directly opposite the male 72 pin edge connector.
19. The “bottom” edge of an expansion card is the edge which has the 72 pin male edge connector.
20. The “obverse” of an expansion card PCB is the side visible when the PCB is held such that the front edge is on the left, and the rear edge is on the right, with the top edge above the bottom.

[1] This includes FPGA and microcontroller-based CPU emulations.

21. The “reverse” of an expansion card PCB is the side opposite the face.
22. The “top” of a backplane is the side into which expansion cards are inserted.
23. The “back” of a backplane is the side opposite the top.

1. Bus Signals

1. The bus which is covered by this standard is carried on female edge connectors with a pin pitch of 2.54mm.
2. Unless otherwise specified in the standard, the pins of the male edge connector on a conforming expansion card MUST measure 1.524mm wide by 7.62mm tall.
3. Through-hole female connectors are recommended for mechanical strength.
4. The bus consists of 50 signals with a 72-pin edge connector[2].
5. The bus singals, and their pin assignments are as defined in table 1 below.
6. The phsyical arrangement of pins is illustrated in figure 1 below.
7. Pins are numbered from pin 1, the pin closest to the rear edge of the PCB on the reverse, to pin 2, the pin closest to the rear edge of the PCB on the obverse, and so on, with the even numbered pins on the obverse, and the odd numbered pins on the reverse.
8. All signals are specified to use 3.3V logic levels, and are assumed to be 5V-intolerant.
9. Each signal on the connector is adjacent to a ground pin, either on the same side of the connector or directly opposite.
10. A conforming backplane MUST provide, for each expansion slot, EITHER a two pin 2.54mm pitch pin header OR a SPST switch, which links the /INT2IN and /INT2OUT pins when connected.
11. A conforming expansion card MUST pass signals from /INT2IN to /INT2OUT, even if it does not use those pins itself.
12. A conforming expansion card which makes use of the /INT2OUT signal MUST block signals from /INT2IN at any time when it is asserting the /INT2OUT signal.
13. A conforming expansion card MAY connect unidirectional TVS diodes between all data lines and ground, physically near the card edge connector. If TVS diodes are present:
    A. Such TVS diodes MUST be rated for a minimum of 50MHz during normal operation, AND
    B. Such TVS diodes MUST have a junction capacitance not exceeding 5pF.
14. A conforming backplane which provides externally-accessible ports MAY connect unidirectional TVS diodes between the pins of those ports and ground. If TVS diodes are present:

---

[2] An example connector part which might be used is the EDAC 395-072-520-201.

   A. Such TVS diodes MUST be rated for a minimum of 50MHz during normal operation, AND
   B. Such TVS diodes MUST have a junction capacitance not exceeding 5pF.

15. A conforming backplane, which provides more than eight expansion slots, MUST provide implementaton-defined signal buffering of the address and data lines, with no less than one set of buffers for every eight expansion slots.
16. A conforming backplane have implementation-defined logic such that bridging and disconnecting of an empty slot's /INT2IN and /INT2OUT pins is automatic.
    A. Such a conforming backplane is exempt from having to include pin headers or SPST switches to handle Mode 2 interrupt daisy-chaining.

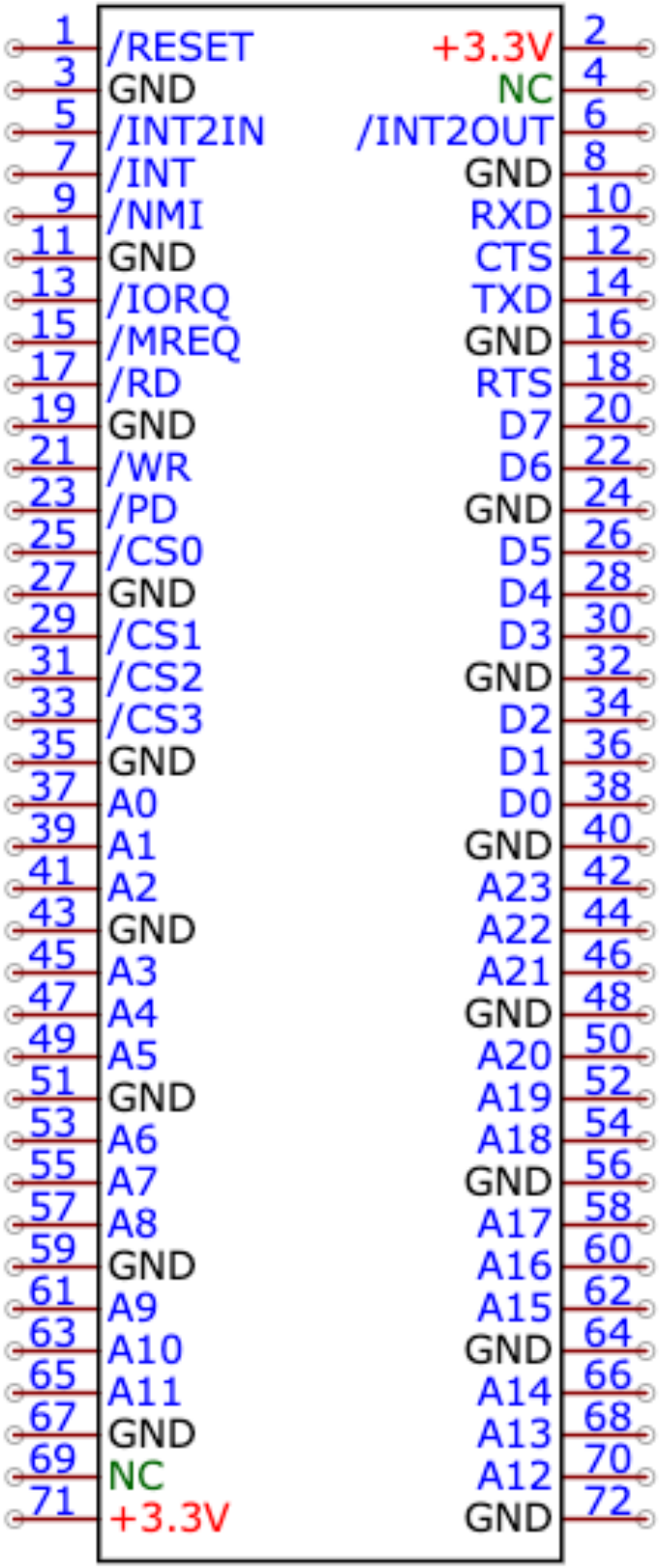

Figure 1: System Bus Connector Pinout

Pin Name	Pin Number	Desciption
+3.3V	2, 71	+3.3 volt power rail
A0..A23	37, 39, 41, 45, 47, 49, 53, 55, 57, 61, 63, 65, 70, 68, 66, 62, 60, 58, 54, 52, 50, 46, 44, 42	24-bit address bus
/MREQ	15	Memory request (active-low)
/IORQ	13	I/O request (active-Llw)
/RD	17	Bus read (active-low)
/WR	21	Bus write (active-low)
/INT	7	Interrupt (active-low)
/NMI	9	Non-maskable interrupt (active-low)
D0..D7	38, 36, 34, 30, 28, 26, 22, 20	8-bit data bus
RXD	10	+3.3V serial recieve
TXD	14	+3.3V serial transmit
CTS	12	+3.3V serial “clear to send” handshake line
RTS	18	+3.3V serial “ready to send” handshake line
/INT2OUT	6	Mode 2 interrupt daisy-chain output (active-low)
/INT2IN	5	Mode 2 interrupt daisy-chain input (active-low)
/CS0../CS3	25, 29, 31, 33	“Chip select” lines (active-low)
/PD	23	Presence detect (active-low)
GND	3, 11, 19, 27, 35, 43, 51, 59, 67, 72, 64, 56, 48, 40, 32, 24, 16, 8	Ground
NC	4, 69	No connection

Table 1: Pin and Signal Descriptions

2. Physical Requirements

1. A conforming backplane MUST place its expansion slots at a centre-to-centre distance from each other of exactly 20.32mm.
2. A fully-assembled conforming expansion card must measure no more than 18mm tall when laid on a flat surface with the reverse side down.
3. A given expansion slot in a conforming backplane may be designated “external” or “internal”.
    A. An internal expansion slot is an expansion slot which is intended for use with expansion cards which lack externally-usable ports or connections.
    B. An external expansion slot is any expansion slot which is intended for use with expansion cards having externally-usable ports or connections.
4. A conforming backplane MUST locate all external expansion slots such that the external connectors on expansion cards used in those slots are visible when the backplane is installed in a compatible case.
5. A conforming backplane MUST locate all internal expansions slots such that no expansion card with a “Keystone” bracket installed may be inserted into the slot.
6. A conforming backplane MAY be physically compatible with any existing case mounting standard.
    A. Such a backplane MUST be clearly marked as to which case mounting standard it is compatible, on the side with the conformance mark(s).
7. A conforming expansion card MUST have board dimensions of no less than 99.5mm (measured from the front to rear edges), no less than (75mm measured from bottom to top edges.
8. A conforming expansion card MUST have board dimensions of no greater than 200mm (measured from the front to rear edges) and no greater than 75mm (measured from the bottom to top edges).
9. Conforming expansion cards are classified by front-to-rear-edge measurement as follows:
    A. A conforming expansion card with a front-to-rear-edge measurement of exactly 99.5mm is a class A expansion card.
    B. A conforming expansion card with a front-to-rear-edge measurement of greater than 99.5mm but no more than 150mm is a class B expansion card.
    C. A conforming expansion card with a front-to-rear-edge measurement of greater than 150mm but no greater than 200mm is a class C expansion card.
10. A conforming expansin card’s rear edge MUST be located at an offset of 8.06mm from the centre of pin 1.

11. A conforming expansion card's ZSA bus edge connector must have measurements of exactly 7.72mm (measured from the bottom edge to the top of the edge connector) and exactly 93.9mm (measured from the front to rear edges of the edge connector).
12. A conforming expansion card design MAY make "cutouts" into the top or front-facing edges of the PCB to allow for connecting "IDC" style ribbon cable edge connectors to the board.
    A. Such cutouts SHOULD remove no more material from the specified board outline than is necessary to securely connect the required connector.
    B. Such cutouts MUST not be made closer than 5mm to the edge of any mounting hole.
    C. Such additional edge connectors may not cause the width or height of a conforming expansion card to exceed the limits in §2.6 an §2.7.
13. A conforming expansion card MAY place two-row, 2.54mm pitch pin headers positioned parallel to the PCB, mounted to the top- or front-facing edge of the expansion card PCB.
14. A conforming expansion card MUST have 45° bevels on the bottom corners of the edge connector, each forming a right triangle with the perpendicular sides each measuring 1mm in length.
15. A conforming expansion card MAY have corner bevels as described in §2.14 on any or all other corners of the PCB.
16. A conforming expansion card SHOULD have the mating edge of the PCB chamfered.
17. A conforming expansion card MUST have a nominal thickness of 1.6mm.
18. A conforming expansion card MUST have mounting holes located at the following places on the board:
    A. A 3.2mm hole located at a centre-to-centre offset, from the center of pin 1 of the edge connector, of 4.86mm towards the rear edge of the PCB, and centre-of-hole offset from the bottom edge of the edge connector of 11.882mm towards the top edge.
    B. A 3.2mm hole located at a centre-to-centre offset, from the center of pin 1 of the edge connector, of 4.86mm towards the rear edge of the PCB, and centre-of-hole offset from the bottom edge of the edge connector of 68.58mm towards the top edge.
    C. A 3.2mm hole located at a centre-to-centre offset, from the center of pin 1 of the edge connector, of 85mm towards the front edge of the PCB, and centre-of-hole offset from the bottom edge of the edge connector of 68.58mm towards the top edge.
19. The measurements and board outline of a conforming expansion card are illustrated in figure 2 below.
20. A conforming expansion card MAY place rear-facing connectors, such as (but not limited to) D-subminature connectors, in the area between the two Keystone 9202 mounting holes on the rear-facing edge of the PCB.

   A. Such connectors, when possible, MUST be positioned such that existing, off-the-shelf, pre-fabricated Keystone-compatible brackets can be affixed to the PCB.

   B. When no existing off-the-shelf, pre-fabricated Keystone-compatible bracket is available to match an expansion card, a conforming expansion card MUST be accompanied by a technical drawing specifying the required cutout(s) to be made in a Keystone-compatible bracket.

21. A conforming backplane MAY provide one or more slots intended for use with removable “cartridges” containg ROM and/or RAM memory, holding program code and data.

   A. Such a backplane MAY use any of the bus signals in such a “cartridge slot”, in an arrangement or pinout that is implementation-defined.

   B. Suchg a backplane MAY implement its system ROM(s) on such a cartridge.

   C. Such a backplane MUST ensure that the requirements for all signals used in a “cartridge slot” are met as if they were used in a regular expansion slot.

   D. Such “cartridge slots” MUST be visibly distinct from, and physically incompatible with, standard expansion cards.

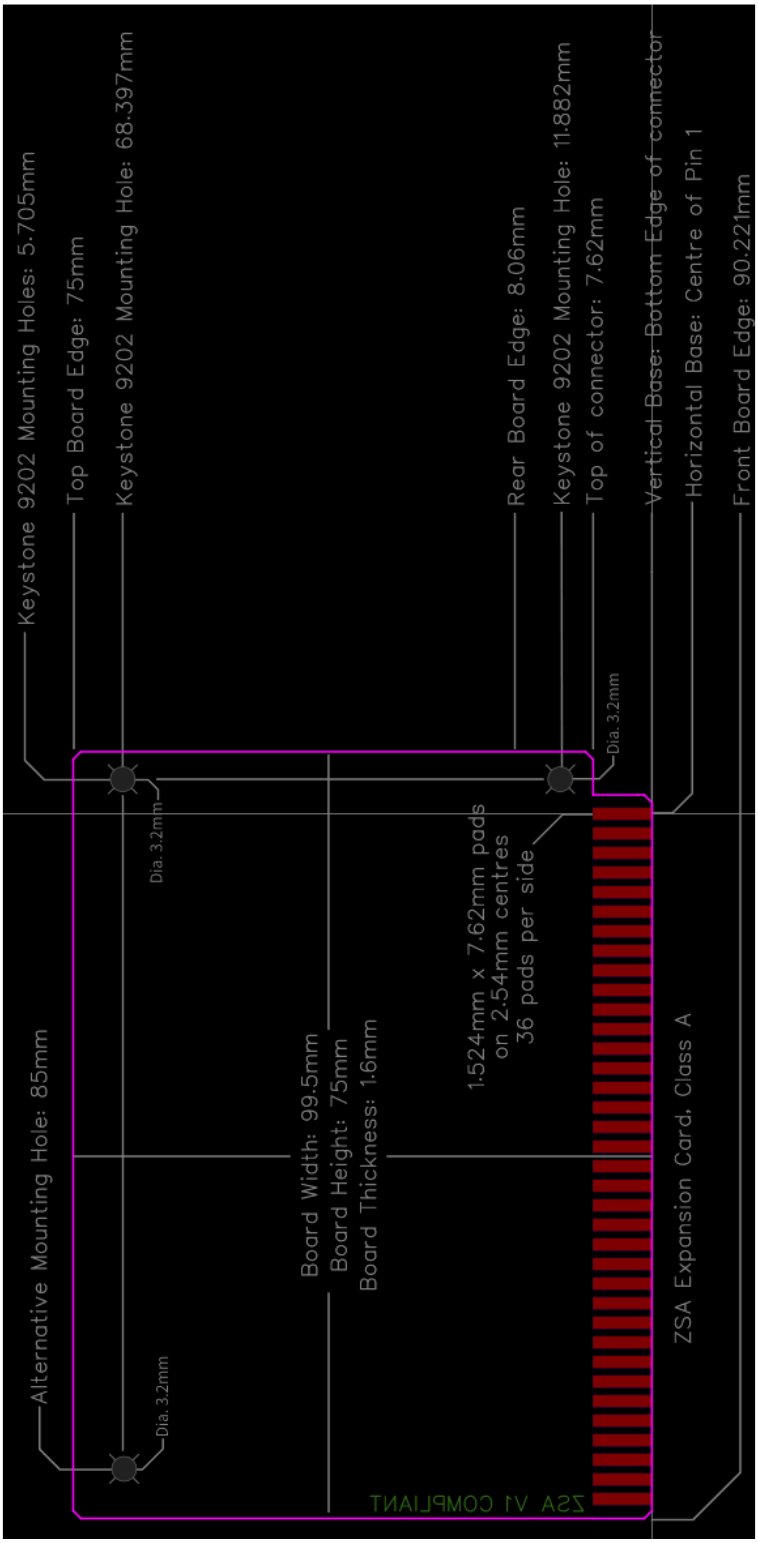

Figure 2: ZSA Expansion Card Specifications

3. Electrical Requirements

1. A conforming backplane MUST safely provide no less than 2500mA of peak current on the 3.3V power rail, with no less than 2000mA safe continious current.
2. A conforming expansion card MUST draw no more than a peak total of 500mA on the +3.3V rail, and no more than 400mA of continuous current.
3. A conforming expansion card MAY make use of a supplemental power source, provided that power source is referenced to the same gound level as the +3.3V rail.
    A. Such supplemental power MUST NOT be connected directly to the +3.3V rail.[3]
    B. A card which makes use of supplemental power source(s) MUST note, in the silkscreen on the card, the voltage, pinout, and current requirements of the supplemental power source.
4. A conforming backplane MAY use any power supply design or connector which safely provides at least the minimum required current on the positive voltage rail.
5. A conforming impelmentation MUST ensure that all PCB traces for the address and data signals have a characteristic impedance of 50Ω ± 10%.
6. A conforming implementation MUST ensure that all PCB traces have an adjacent reference plane to provide a low impedance path for return currents and minimise the risk of signal integrity issues.
    A. A conforming implementation utilising a two-layer PCB SHOULD route all signal traces on one layer and place an unbroken ground plane on the other layer.
    B. A conforming implementation utilising a four-layer PCB SHOULD arrange the layers as follows: Two inner ground layers, in between two outer layers which have signals and +3.3V power.
    C. A conforming implementation utilising a PCB with six or more layers SHOULD ensure that each signal layer references a plane on the same side of the core.
7. A conforming implementation MAY integrate the functionality of a backplane with that of various other devices, such as serial UARTs, memory, or even CPU, into a single unified “motherboard” PCB.
    A. Such an implementation MUST include at least two expansion card slots.
    B. Such an implementation is considered a backplane for the purposes of standard conformance.
8. A conforming implementation which makes available, on an external connector, the four “serial” signals (RXD, TXD, RTS, and CTS) of the system

[3] An example of this would be a 4-pin Molex style connector using one of an ATX power supply’s drive plugs to add a +5V and +12V rail for use on the card.

bus MUST provide appropriate level shifting for the external connector used.

4. Software Requirements

1. A conforming implementation which includes a CPU other than a coprocessor MUST implement execution of Z80 compatible opcodes.
2. A conforming implementation which includes a CPU other than a coprocessor MUST implement a “Basic Input/Output System” (BIOS) compatible with that of CP/M 2, or, at the implementer’s option, any later version.
3. A conforming implementation which includes a CPU other than a coprocessor MUST implement the “ZSA BIOS Extensions” (ZBIOS) interface listed in the appendices.
4. A conforming expansion card MUST be accompanied by a documented public software interface to the hardware it exposes to the system bus.
5. A conforming implementation which includes a coprocessor which is capable of “taking over” the system bus MUST include in its documented public software interface a method for returning control of the system bus to the main CPU.

5. Licensing Requirements

1. This standard is made available under the CERN Open Hardware License, version 1.2, or, at the licensee's preference, any later version.
   A. A copy of the text of the CERN Open Hardware License, version 1.2, is located in the appendices of this document.
2. A conforming implementation's schematic diagram(s) and accompanying documentation as required by the standard MUST be made available under the terms of the CERN Open Hardware License, version 1.2, or, at the designer and/or licensee's preference, any later version.

Appendix A

ZSA BIOS Extension (ZBIOS)

Appendix B

CERN Open Hardware License, Version 1.2

Preamble

Through this CERN Open Hardware Licence ("CERN OHL") version 1.2, CERN wishes to provide a tool to foster collaboration and sharing among hardware designers. The CERN OHL is copyright CERN. Anyone is welcome to use the CERN OHL, in unmodified form only, for the distribution of their own Open Hardware designs. Any other right is reserved. Release of hardware designs under the CERN OHL does not constitute an endorsement of the licensor or its designs nor does it imply any involvement by CERN in the development of such designs.

1. Definitions

In this Licence, the following terms have the following meanings:

"Licence" means this CERN OHL.

"Documentation" means schematic diagrams, designs, circuit or circuit board layouts, mechanical drawings, flow charts and descriptive text, and other explanatory material that is explicitly stated as being made available under the conditions of this Licence. The Documentation may be in any medium, including but not limited to computer files and representations on paper, film, or any other media.

"Documentation Location" means a location where the Licensor has placed Documentation, and which he believes will be publicly accessible for at least three years from the first communication to the public or distribution of Documentation.

"Product" means either an entire, or any part of a, device built using the Documentation or the modified Documentation.

"Licensee" means any natural or legal person exercising rights under this Licence.

"Licensor" means any natural or legal person that creates or modifies Documentation and subsequently communicates to the public and/ or distributes the resulting Documentation under the terms and conditions of this Licence.

A Licensee may at the same time be a Licensor, and vice versa.

Use of the masculine gender includes the feminine and neuter genders and is employed solely to facilitate reading.

2. Applicability

2.1. This Licence governs the use, copying, modification, communication to the public and distribution of the Documentation, and the manufacture and distribution of Products. By exercising any right granted under this Licence, the Licensee irrevocably accepts these terms and conditions.

2.2. This Licence is granted by the Licensor directly to the Licensee, and shall apply worldwide and without limitation in time. The Licensee may assign his licence rights or grant sub-licences.

2.3. This Licence does not extend to software, firmware, or code loaded into programmable devices which may be used in conjunction with the Documentation, the modified Documentation or with Products, unless such software, firmware, or code is explicitly expressed to be subject to this Licence. The use of such software, firmware, or code is otherwise subject to the applicable licence terms and conditions.

3. Copying, modification, communication to the public and distribution of the Documentation

3.1. The Licensee shall keep intact all copyright and trademarks notices, all notices referring to Documentation Location, and all notices that refer to this Licence and to the disclaimer of warranties that are included in the Documentation. He shall include a copy thereof in every copy of the Documentation or, as the case may be, modified Documentation, that he communicates to the public or distributes.

3.2. The Licensee may copy, communicate to the public and distribute verbatim copies of the Documentation, in any medium, subject to the requirements specified in section 3.1.

3.3. The Licensee may modify the Documentation or any portion thereof provided that upon modification of the Documentation, the Licensee shall make the modified Documentation available from a Documentation Location such that it can be easily located by an original Licensor once the Licensee communicates to the public or distributes the modified Documentation under section 3.4, and, where required by section 4.1, by a recipient of a Product. However, the Licensor shall not assert his rights under the foregoing proviso unless or until a Product is distributed.

3.4. The Licensee may communicate to the public and distribute the modified Documentation (thereby in addition to being a Licensee also becoming a Licensor), always provided that he shall:

a) comply with section 3.1;

b) cause the modified Documentation to carry prominent notices stating that the Licensee has modified the Documentation, with the date and description of the modifications;

c) cause the modified Documentation to carry a new Documentation Location notice if the original Documentation provided for one;

d) make available the modified Documentation at the same level of abstraction as that of the Documentation, in the preferred format for making modifications to it (e.g. the native format of the CAD tool as applicable), and in the event that format is proprietary, in a format viewable with a tool licensed under an OSI-approved license if the proprietary tool can create it; and

e) license the modified Documentation under the terms and conditions of this Licence or, where applicable, a later version of this Licence as may be issued by CERN.

3.5. The Licence includes a non-exclusive licence to those patents or registered designs that are held by, under the control of, or sub-licensable by the Licensor, to the extent necessary to make use of the rights granted under this Li-

cence. The scope of this section 3.5 shall be strictly limited to the parts of the Documentation or modified Documentation created by the Licensor.

4. Manufacture and distribution of Products

4.1. The Licensee may manufacture or distribute Products always provided that, where such manufacture or distribution requires a licence under this Licence the Licensee provides to each recipient of such Products an easy means of accessing a copy of the Documentation or modified Documentation, as applicable, as set out in section 3.

4.2. The Licensee is invited to inform any Licensor who has indicated his wish to receive this information about the type, quantity and dates of production of Products the Licensee has (had) manufactured

5. Warranty and liability

5.1. DISCLAIMER – The Documentation and any modified Documentation are provided "as is" and any express or implied warranties, including, but not limited to, implied warranties of merchantability, of satisfactory quality, non-infringement of third party rights, and fitness for a particular purpose or use are disclaimed in respect of the Documentation, the modified Documentation or any Product. The Licensor makes no representation that the Documentation, modified Documentation, or any Product, does or will not infringe any patent, copyright, trade secret or other proprietary right. The entire risk as to the use, quality, and performance of a Product shall be with the Licensee and not the Licensor. This disclaimer of warranty is an essential part of this Licence and a condition for the grant of any rights granted under this Licence. The Licensee warrants that it does not act in a consumer capacity.

5.2. LIMITATION OF LIABILITY – The Licensor shall have no liability for direct, indirect, special, incidental, consequential, exemplary, punitive or other damages of any character including, without limitation, procurement of substitute goods or services, loss of use, data or profits, or business interruption, however caused and on any theory of contract, warranty, tort (including negligence), product liability or otherwise, arising in any way in relation to the Documentation, modified Documentation and/or the use, manufacture or distribution of a Product, even if advised of the possibility of such damages, and the Licensee shall hold the Licensor(s) free and harmless from any liability, costs, damages, fees and expenses, including claims by third parties, in relation to such use.

6. General

6.1. Except for the rights explicitly granted hereunder, this Licence does not imply or represent any transfer or assignment of intellectual property rights to the Licensee.

6.2. The Licensee shall not use or make reference to any of the names (including acronyms and abbreviations), images, or logos under which the Licensor is known, save in so far as required to comply with section 3. Any such permitted use or reference shall be factual and shall in no event suggest any kind of endorsement by the Licensor or its personnel of the modified Documentation or

any Product, or any kind of implication by the Licensor or its personnel in the preparation of the modified Documentation or Product.

6.3. CERN may publish updated versions of this Licence which retain the same general provisions as this version, but differ in detail so far this is required and reasonable. New versions will be published with a unique version number.

6.4. This Licence shall terminate with immediate effect, upon written notice and without involvement of a court if the Licensee fails to comply with any of its terms and conditions, or if the Licensee initiates legal action against Licensor in relation to this Licence. Section 5 shall continue to apply.

End of license text