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PhotoSound LEGION
Hardware configuration and probe interface
2019-04-12

ADC256 Revision 1.0 and 1.1

This is the supplementary document for describing input options available for Legion ADC and DAQ family as well as channel mapping for various systems. Normally channel .map file is supplied as a part of Legion software and is not required for end users.

The user manual is subject to change without notice, registered LEGION system users will receive up to date version of the user manual as a part of the support plan for their system. This user manual cannot be distributed without the explicit permission of PhotoSound.

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Legion system configurations

Complete DAQ system with Legion DAQ or ADC for Photoacoustics consists of the probe array, optional preamplifier and Legion ADC board. Legion ADC systems are typically used with preamplifiers supplied by the end users, which might be integrated with or inside the active probe.

Legion data acquisition system can be supplied in multiple configurations. The base building block of Legion system is ADC256, which is used in all Legion systems, except standalone Legion amplifier:

- Current ADC/DAQ128 use the same ADC256 hardware restricted for operation with 128-channels only. ADC/DAQ128 can be upgraded to 256-channels on firmware level by purchasing upgrade license and extra adapter or preamplifier options, if needed.
- ADC/DAQ systems with more of 256-channels consist of multiple 256-ch boards running under the same software interface.

The probe is characterized by the probe interface, which is described by selection of the probe connector and probe connector pinout. Currently PhotoSound supporting Cannon DLC260 (Figure 1 and Figure 2), DLM156 (Figure 3), and Harting 68-pin (SCSI-68) connectors as AMP128 preamplifier inputs. Support of Cannon DLM260 and Hirose EX 280-pin connectors is planned for ADC128 DAQ preamplifiers. Physical design of preamplifier board depends not only on connector model selection, but also connector pinout. Pinout is a signal (net) assignment for connector pins. Probes with identical connector models, but different pinouts might be not compatible. If the signal pin positions are matching between two pinouts, pinouts are compatible, but have different pin maps. Pin maps are discussed in the last section of this document *Channel Map and Pinout Tables.* If signal pin positions do not match between pinouts, the pinouts are incompatible and require physically different preamplifier or adapter boards. The exception, the probes with reduced number signal pins can be used instead of the probe with larger number of signal pins, if all signal pins of the smaller probe are matching the signal pins of the larger probe.

PhotoSound use Legion series 128-channel preamplifier boards with Legion DAQ series and Legion standalone preamplifier. The channel number limitation is dictated by available connector selection and preamplifier board component count. Ideally probe connectors should have pin count double the channel count with 50% ground pins evenly distributed between channel pins. Cannon QLC260 and Hirose EX 280-pins satisfies this requirement. Common pinout for Cannon DLM156 has too small number of ground pins, which cause increase EMI pickup and crosstalk. Common pinout for Cannon DLM260 has too sufficient number of pins, but all signal pins are bundled close together without ground pins in between, which reduce connector performance.

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According to common grounding scheme described in classical Henry Ott *Electromagnetic Compatibility Engineering* book all signal ground and shield ground have to be connected together on both sides of the probe cable. This grounding scheme can be easily implemented on preamplifiers with Cannon QLC260 and Hirose EX 280-pin or SCSI-68 connectors at least on preamplifier end, but hard with Cannon DLM connectors. Insufficient shielding of Cannon DLM connectors can case increased noise pickup.

Input options, DAQ

A system of two identical AMP128 boards and an ADC256 is classified as a DAQ256 board, this labeling convention will be explained in the *Input options, DAQ* section. A mix and match of different AMP128 and breakout boards is possible, though the user will have to reference the Custom Configurations section of this manual for successful operation.

The LEGION DAQ256 (x2 AMP128 + ADC256) system has is a different class of product from the ADC256 because of it is a complete data acquisition suite. The DAQ256, excluding custom probe rewiring, comes ready to use out of the box with the supplied *PhotoSound Data Acquisition Application*. Minimal configuration is needed, representing a polished DAQ solution for the consumer. The DAQ256 has the same available connectors as any AMP128 board configuration: QLC260 (Figure 1 and Figure 2), DLM156 (Figure 3), DLM260, and SCSI-68.

Figure 1: LEGION DAQ256 = ADC256 + 2x AMP128 with Cannon QLC-260 input connectors.

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Figure 2: LEGION DAQ128 = ADC128 + AMP128 with Cannon QLC-260 input connector.

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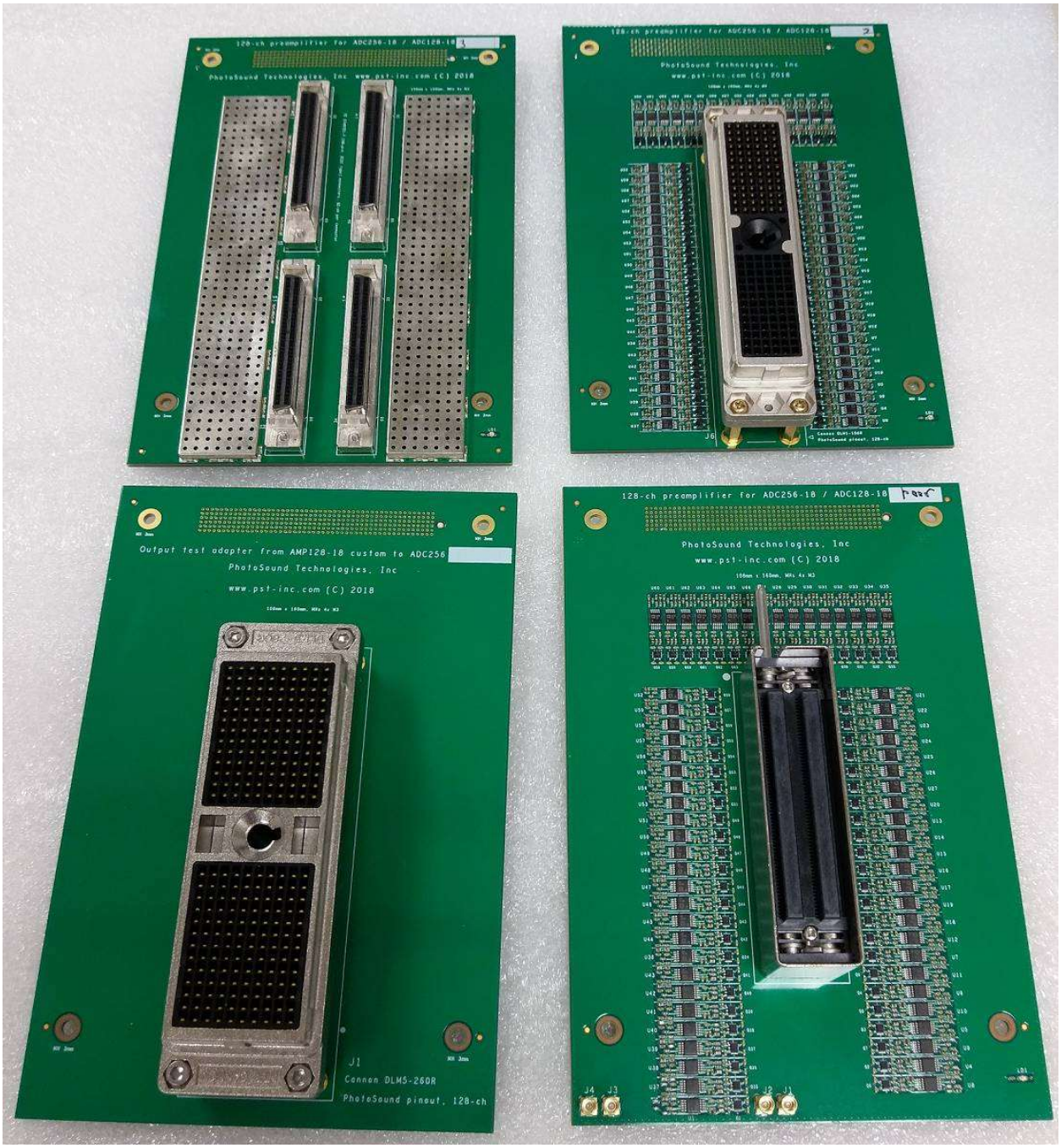

Figure 3: Four different versions of 128-ch preamplifier and adapter boards, 160 mm x 108 mm each with Samtec SEAMP ADC256 connector on PCB bottom (not shown). ADC256 can accept two identical 128-ch boards or any combination.

- *Top-left: AMP128 with 4x 32-ch SCSI-68 type connectors.*
- *Top-right: AMP128 with Cannon DLM-156 input connector.*
- *Bottom-right: Breakout adapter with Cannon DLM-260 input connector (not a preamplifier).*
- *Bottom-right: AMP128 with Cannon QLC-260 probe connector. PhotoSound recommends QLC-260 probe connector.*

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Input options, Legion ADC

The ADC256 board has many different available configurations. The two main configuration options are between installing an AMP128 board or a simpler breakout board onto either the J9 or J10 (

Figure 4) connectors of the ADC256.

The breakout board currently available, designed or produced in the past includes SMA128 (Figure 5, stock item), custom 16x 16-channel SCSI-68 breakout, custom sets 16-channel 2x34 .1" pin arrays boards.

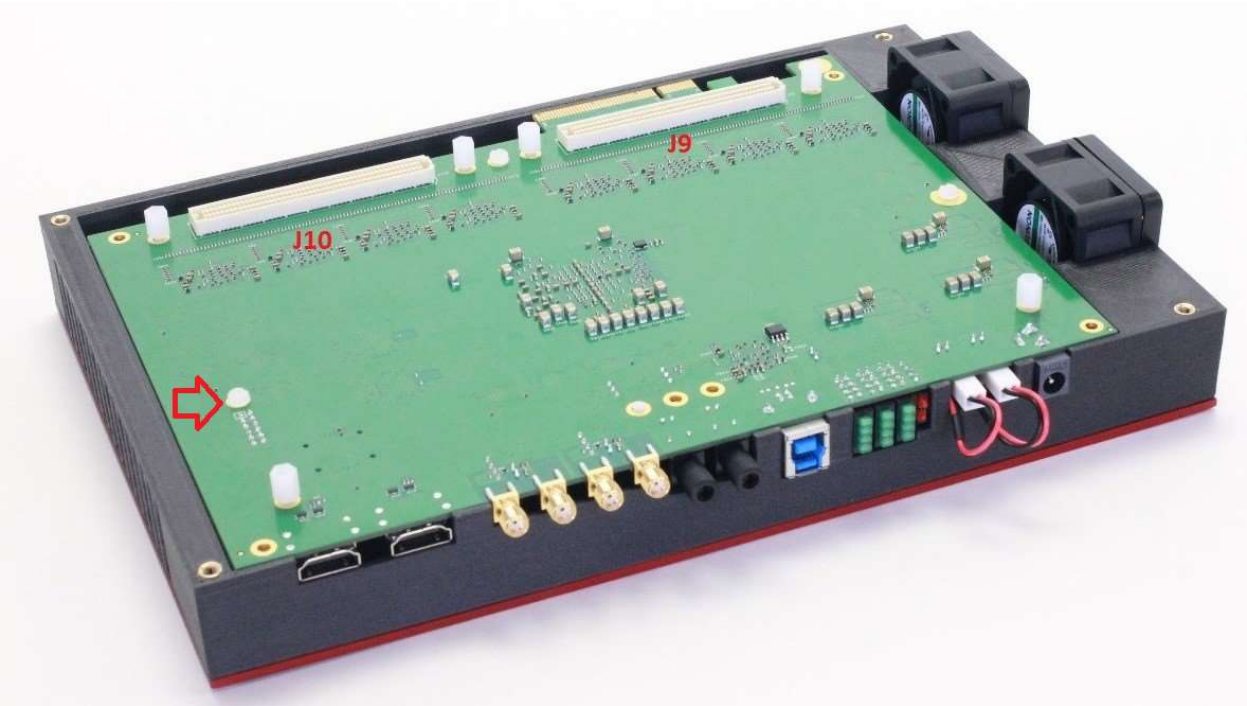

Figure 4: LEGION ADC256 R1.0 with two Samtec SEAFP series input connectors J9 and J10. J9 connector has A32-ch ADC chips 1-4 and J10 connector has ADC chips 5-8. DAQ/ADC128 use only 5-8 ADC chips. ADC256 R1.1 has the same mounting points, except the screw or standoff marked with red arrow. If adapters designed for R1.0 are used with R1.1 and wise versa, remove 7mm M3 plastic standoff from the position marked with red arrow and populate it with M3 6mm long plastic screw, like shown in figure.

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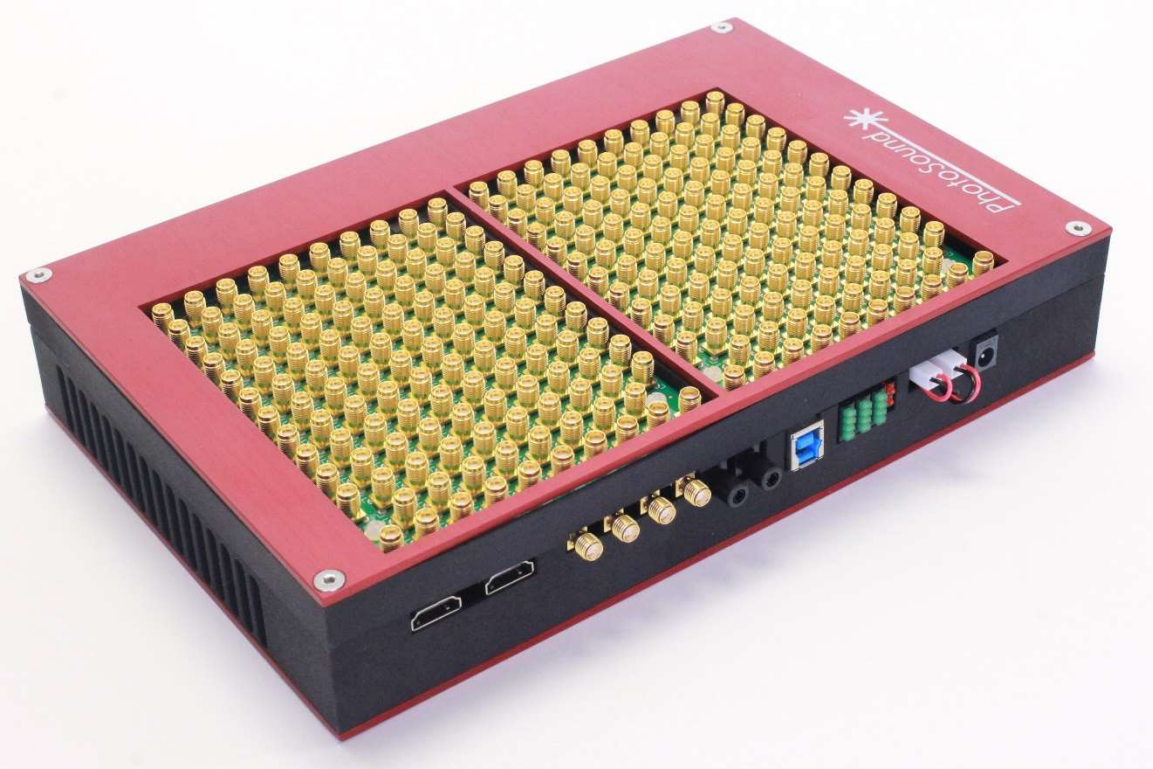

Figure 5: LEGION ADC 256 with two optional LEGION SMA128 breakout boards installed (test configuration).

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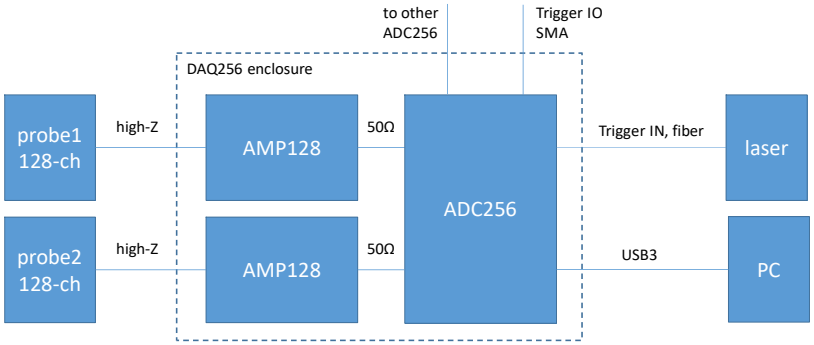
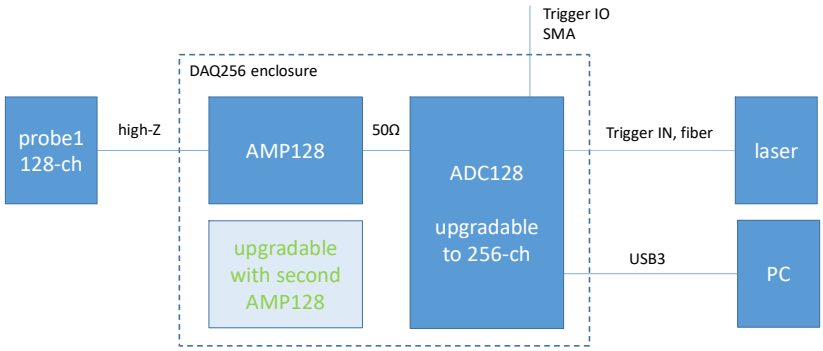
Block diagrams

Legion DAQ256 block diagram, top level



Legion DAQ128 block diagram, top level



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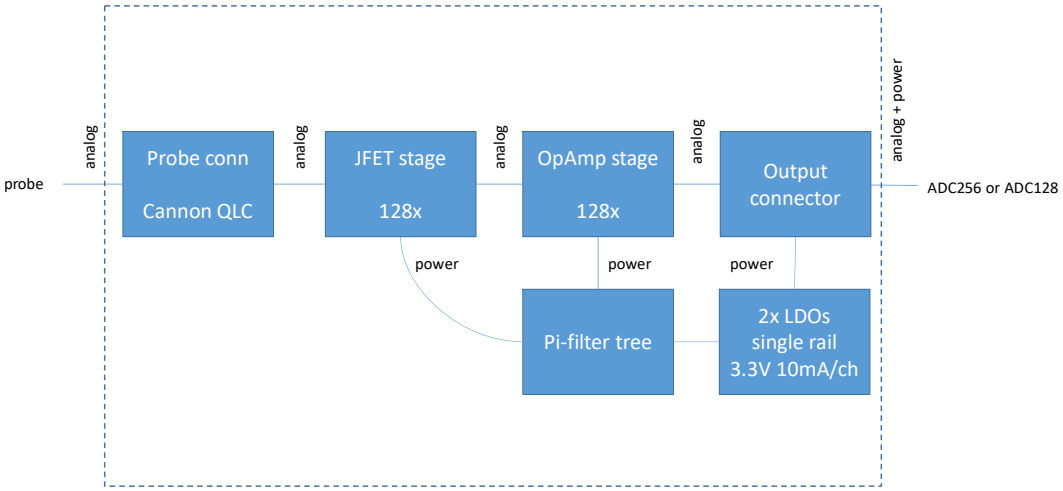
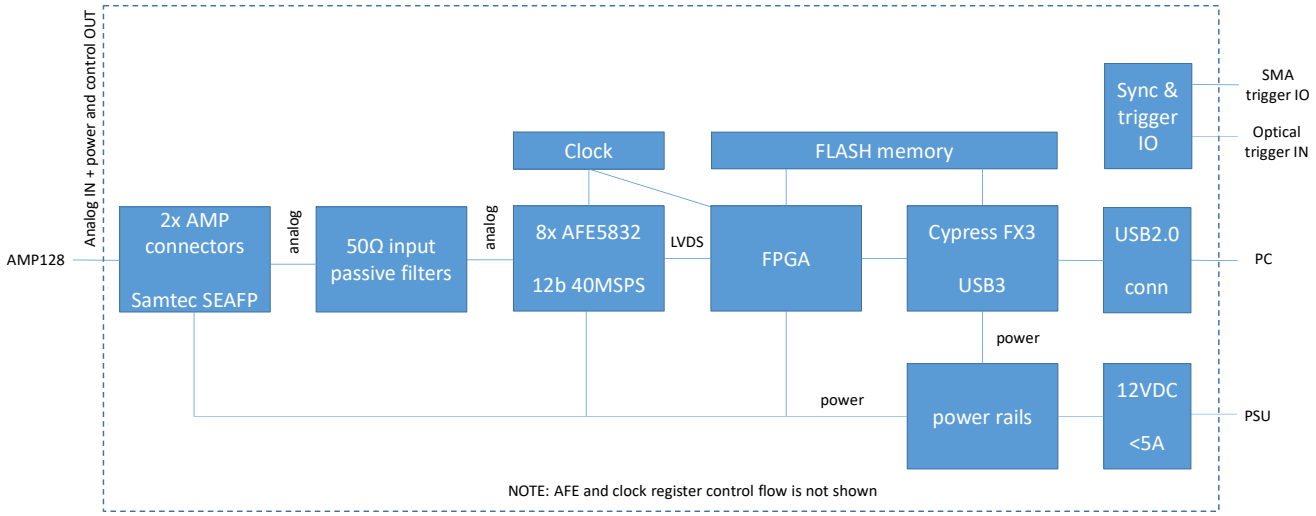
AMP128 block diagram



ADC256 block diagram



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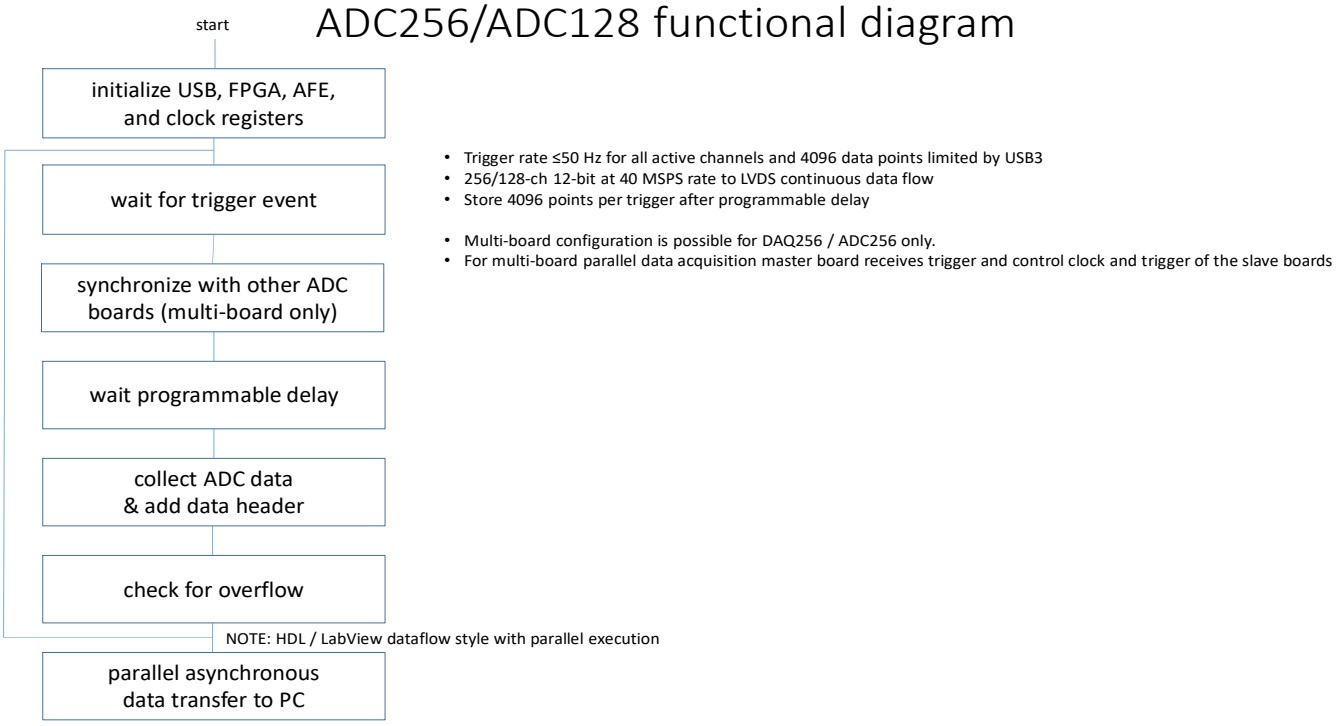
Functional diagram



The signal path from the probe to recorded file and MAP files

The signal path from the probe to the recorded file consists of

- analog signal path:
    1. the probe connector, describe by the probe connector type and pinout.
    2. signal path through the adapter board from the probe input connector to the output SEAMP connector(s)
    3. signal path from ADC SEAFP connector(s) mating adapter SEAMP connector(s) to 8x 32-channel ADC chips,
- digital path from ADC chips to FPGA to USB3 interface to PC memory.

Only the step 3 of the analog path is the same for all Legion DAQ and ADC R1.0 and R1.1 system, except DAQ/ADC128 is using 4 last ADC chips only. The probe connector type and pinout

Analog path is described in Excel file supplied has sheets describing

1. the probe connector pinout table: channel number vs connector pin number,
2. preamplifier or adapter board signal path table: input connector pins vs matching output Samtec SEAMP connector(s) pins,
3. ADC256 signal path table: Samtec SEAFP connectors pins vs ADC channels ADCx_CHy or Ax-Cy,

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4. Aligned signal path from 1 to 3 combined from previously described sheets 1-3,
5. Short combined path with probe channel numbers vs sorted ADC channels in order A1-C1 to A4-C32 or A8-C32.
6. MAP file data = probe channel numbers from the sheet 5.

In order to create combined path on the sheet 4, mating connector pins have to be alleged between the probe output connector and preamplifier input connector, next between preamplifier output connector and ADC input connectors. Generally, the mating connectors have the same number of the signal pins and the pins with identical numbers are connected together. The pin numbers might be numeric for mating Samtec SEAMP and SEAFP connectors 1 – 300, mating 1 – 1, 2 – 2,… 300 – 300 or alpha numeric for Cannon DLM series connectors, mating A1 – A1, A2 – A2,… B1 – B2,… , AA1 – AA1, …

Warnings:

- Connector names, like J9 and J10 and the signal net names are local for each PCB.
- Mating connector reference designators are described in the comments in Excel file and this document.
- Input and output nets for preamplifier boards might different nets. Typically, the net (signal) AinX before preamplifier is matching preamplifier output AoutX to SEAMP connector: Ain1 – Aout1,… Ain128 – Aout128 unless something else is stated.
- Preamplifier board input signal nets labeled as Ain1 to Ain128 are different from the probe channel number. Match pin numbers between probe and preamplifier, not net names.

The standard version of LEGION AMP128 preamplifier has single user accessible probe connector, J6, Cannon QLC-260 with pinout provided as

Standard AMP128 can be used with other pinouts under the condition that the probe's signal pin positions match the AMP128 connector's signal pin positions (No probe signal pins going to the AMP128 connector's GND pins). It is the end user's responsibility to verify the actual pinout with the probe's manufacturer and generate a new .map file. Different signal pin positions and/or different probe connectors might be supported in custom versions of AMP128 (special order).

The final description of the signal path a system specific .MAP file. MAP file is a single column text file, which list probe channel numbers in the order of ADC channel numbers. ADC channels are starting from A1-C1, which is ADC1 channel 1 and ending with A8-C32 for ADC256 or A16-C32 for 512-channel system. After the MAP file is loaded, different channels are displayed as Ax-Cy-Sz, where x is ADC number 1 to 8 for ADC256, y is the channel number always 1 to 32, and z is the probe channel number 1 to 256 for 256 channel system.

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For example, before any MAP file is loaded the first 4 channels of ADC1 will be labeled on the waveform graph as A1-C1, A1-C2, A1-C3, A1-C4. After the probe map starting with 4, 2, 3, 1,… is loaded, the same channels will be labeled as A1-C1-S4, A1-C2-S2, A1-C3-S3, A1-C4-S1.

If DAQ system has multiple identical breakout boards attached, the map file can be constructed for the fist breakout board only. The map for the subsequent breakout board is calculated automatically for all available ADC channels. For example, if the channel map has only 4-positions: 4, 2, 3, 1 it will be extended periodically offset with period and offset equal to the length of the map before extension:
4, 2, 3, 1, 4+4, 2+4, 3+4, 1+4, 4+8, 2+8, 3+8, 1+8, … = 4, 2, 3, 1, 8, 6, 7, 5, 12, 10, 11, 9, …

Channel Map and Pinout Tables

Different probes on the market have different channel maps associated with their connectors. This section will allow a user to generate a *.map file for a 3rd party probe to the ADC256 for data recording. If the user has no issues with probe to ADC mapping, this section should be skipped.

The PST supplied MS Excel files *DAQ256w***### YYYYMMDD.xlsx* has a complete list of all the connector pinouts for typical probes, AMP128-18, SMA128 breakout board, and ADC256. The Excel file sent will correspond to the configuration of the user's DAQ/ADC.

The channel maps provided by PST only contain information of parts made by PST; usually having missing information for 3rd party components. Channel maps of the probe are necessary to devise a signal map of the DAQ256/ADC256 system.

- DAQ256: Requires channel map of the probe and the specific version of preamplifier board
- ADC256: Requires channel map of the probe, preamplifier, and adapter boards.

Connector pinouts with netlists can be extracted from netlist.htm reports. Verify channel map for 3rd party components using manufacturer's datasheets.

Note: ADC chips in *DAQ256w***### YYYYMMDD.xlsx* are indexed from ADC1-ADC8 with channels from IN0-IN31. Other documents and software might index ADC chips from ADC1-ADC8 with channels from IN1-IN32.

The MS Excel files *DAQ256w***### YYYYMMDD.xlsx* has multiple sheets, each detailing either the channel pinout paths or providing signal mappings between probe-amplifier-ADC connectors. All channel map Excel files have common sheets, which will be detailed first. The channel pinout/mapping sheets are listed where ***### are the connectors (Note: NC or Purple highlights stand for Not Connected, since probes with lesser channel pins than the AMP128's 128 channel pins have an injective mapping):

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- ADC256wSMA128 20181207.xlsx
- DAQ256wQLC260 20181207.xlsx
- DAQ256wDLM156 20181207.xlsx
- ADC256wBreakoutff256SCSI16x16 YYYYMMDD.xlsx

Common Sheets

- **A128**: This sheet lists the channel mappings of the AMP128 to both J# connector and J9/10 ADC connector.
  - #: AMP128 channel variable.
  - Net in: AMP128 input channel name (from Connector).
  - J#: Corresponding connector channel pin.
  - Net out: AMP128 output channel name (to ADC256).
  - J129, SEAMP: Matches J9 and J10 channel pin numbers from AMP128 to ADC256.
- **ADC256_J9**: This sheet lists the channel pinouts of the ADC256's J9 connector.
  - #: ADC256 J9 channel variable.
  - Net: ADC256 J9 channel name.
  - J9, SEFAFP: ADC256 J9 matching with ADC256 J10.
  - Rin: ADC256 J9 input resistor name.
  - Cin: ADC256 J9 input capacitor name.
- **ADC256_J10:** This sheet lists the channel pinouts of the ADC256's J10 connector.
  - #: ADC256 J10 channel variable.
  - Net: ADC256 J10 channel name.
  - J10, SEFAFP: ADC256 J10 matching with ADC256 J9.
  - Rin: ADC256 J10 input resistor name.
  - Cin: ADC256 J10 input capacitor name.

DAQ256wAdapter YYYYMMDD.xlsx

DAQ256 is a configuration of two AMP128 preamplifiers + ADC256. This class of file describes the channel maps for DAQ256 configuration with the adapters labeled in the title. The channel map files use an Imasonic 128-ch probe as an example probe input.

- **I-Probe -> ADC256 Expanded**: This sheet provides a channel mapping of AMP128 + ADC256 with generic 96 and 128 channel probe options.
  - a128 #: Amplifier channel pin number.
  - a128_adc_net: Amplifier channel pin name.
  - J#, Adapter: Adapter connector channel pin number.
  - Adapter pin: Adapter connector channel pin name.
  - #1: AMP128 connected to J9 on ADC256 channel variable.

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    - J9 net: AMP128 connected to J9 on ADC256 channel name.
    - #2: AMP128 connected to J9 on ADC256 channel variable.
    - J10 net: AMP128 connected to J10 on ADC256 channel name.
    - J9/J10/J129 pin: Matches J9 and J10 channel pin numbers to ADC256.
    - probe128-ch: Generic 128 channel probe channel pin numbers.
    - probe96-ch: Generic 96 channel probe channel pin numbers.
- **I-Probe Simple**: This sheet provides a simplified view of the **I-Probe -> ADC256 Expanded** sheet, listing only the mapping between probe channels and the J9/10 channel variables on the ADC256.
    - ADC1-4: J9 channel variables, same as #1 on the **I-Probe -> ADC256 Expanded.**
    - ADC5-8: J10 channel variables, same as #2 on the **I-Probe -> ADC256 Expanded.**
    - probe128-ch: Generic 128 channel probe channel pin numbers.
    - probe96-ch: Generic 96 channel probe channel pin numbers.
- **I-Probe -> Adapter -> A128 Expanded**: This sheet provides a channel mapping of Adapter + AMP128 with generic 96 and 128 channel probe options.
    - (Adapter)#: Adapter channel variable.
    - Adapter pin: Adapter channel name.
    - AMP128-18: AMP128-18 channel name.
    - AMP128-18 (Highlighted): AMP128-18 channel variable.
    - Imasonic128: Imasonic 128 channel name.
    - probe128-ch: Imasonic 128 channel variable.
    - Imasonic96: Imasonic 96 channel name.
    - probe96-ch: Imasonic 96 channel variable.
- **I-Probe -> Adapter -> A128 Simple**: This sheet provides a simplified view of the **I-Probe -> Adapter -> A128 Expanded** sheet, listing only the mapping between probe, QLC, and AMP128 channel names.
    - (Adapter) #: Adapter channel variable.
    - Adapter pin: Adapter channel name.
    - Imasonic128: Imasonic 128 channel probe channel names and GND pin designations map to Adapter.
    - Imasonic96: Imasonic 96 channel probe channel names and GND pin designations map to Adapter.
    - AMP128-18: AMP128-18 channel names and GND pin designations map from Adapter.

Note: All connector reference designators are local to PCBs. J6, QLC probe adapter connector on the AMP128 is NOT the same connector as the J6 fan power on the ADC256.

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ADC256wSMA128 20181207.xlsx

SMA128 breakout board is a board with 128x SMA input connectors and SEAMP output connector. The board is equipped with ESD protection diodes, but does not have PIN diodes or other safety protection. It is the user's responsibility to restrict input signals into the ADC to a safe level.

- **2x SMA128 -> ADC**: This sheet provides a channel mapping of a 2 SMA128 + ADC256.
  - #: SMA128 channel variable.
  - SMA128: SMA128 channel name.
  - #1: SMA128 connected to J9 channel variable.
  - J9 net: SMA128 connected to J9 channel name.
  - #2: SMA128 connected to J10 channel variable.
  - J10 net: SMA 128 connected to J10 channel name.
  - J9/J10/J129 pin: Matches J9 and J10 channel pin numbers to ADC256.
- **SMA128:** This sheet lists the channel mapping of the SMA128 to ADC256.
  - #: SMA128 channel variable.
  - Net: SMA128 input channel name (from probes).
  - SMA: SMA128 channel name etched onto PCB
  - J129, SEAMP: Matches J9 and J10 channel pin numbers from SMA128 to ADC256.

ADC256wBreakoutff256SCSI16x16 YYYYMMDD.xlsx

ff256 Harting-68 is a custom breakout (feedthrough) board with 16x 16-channel Harting-68 (SCSI-68) analog connectors. Board signal path is described in a separate Excel file and loaded to ADC256 as *ADC256wBreakoutff256SCSI16x16 YYYYMMDD.map* file.

- **Generic Probe:** This sheet lists the channel mappings of a generic probe
  - Probe ch: Probe channel variable.
  - Probe Net: Probe channel name.
  - Probe Output: Output connector of probe pin variable.
  - Probe Output pin: Probe output pin variable.
- **Breakout:** This sheet lists the channel mapping of the ff256 Harting-68 custom breakout
  - Breakout Input: Input connector of breakout board pin variable.
  - Breakout Input pin: Breakout input pin variable.
  - Breakout Output: Output connector of breakout output pin (Note: J17 -> J9 & J18 - > J10 in Breakout -> ADC connector map).
  - Breakout Output pin: Breakout output pin variable.
- **ADC256:** This sheet lists the channel mapping of the ADC256
  - ADC Input: Input connector of the ADC Input pin variable.
  - ADC Input pin: ADC input pin variable.

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    - ADC #: ADC256 channel variable.
    - Net: ADC256 channel name.
- **G-Probe -> Breakout -> ADC256:** Full Probe to ADC signal mapping. If sorted by ADC # then Probe ch is the *.map file. Red test columns see if there is a mismatch between any of the labeled connectors. If Test: Summary has a value of "Pass", then all signal maps are correct. The sheet is color coded for easy identification of connections.
- **G-Probe -> ADC256:** A simple signal mapping of Probe to ADC. This sheet only shows the end result of the channel mapping.
- **map:** The channel map that is exported as a *.map file for the *PhotoSound Data Acquisition Application*.

User Setup

2x SMA128 -> ADC256

The following procedure should be used for all SMA128 + ADC256 combinations.

1. Determine which ADC256 connector the SMA128 is attached to (J9 or J10) in the **2x SMA128 -> ADC** sheet.
2. Use the highlighted SMA128 column's channel names to cross reference the J9/J10 ADC256 channel name.
3. Sort by #1 for J9/#2 for J10, the green # column is the channel map. Copy the column and paste it as a *.txt file, save the file with a *.map extension and place it into the same folder as the *PhotoSound Data Acquisition Application*.
4. In the Plot tab of the *PhotoSound Data Acquisition Application*, there is a channel map load box. Find the *.map file and load it into the program.
5. Observe channel signals through *PhotoSound Data Acquisition Application.*

Advanced users can recreate the **2x SMA128 -> ADC** sheet by combining **SMA128, ADC256_J9,** and **ADC256_J10** through the J129 mapping.

DAQ256 (2x AMP128 + ADC256) w/ QLC260 Adapter

The DAQ256 setup is more complex than the SMA128 setup because of the inconsistency of 3rd party probe channel variables. In order to create a mapping, the following procedure must be completed (Note: This procedure should be followed for all other DAQ256 connectors):

1. Determine which ADC256 connector the AMP128 is attached to (J9 or J10) in the **I-Probe -> ADC Expanded** sheet.
2. Use the highlighted J6, QLC column's channel variables to cross reference the J9/J10 net ADC256 channel name (it might also be useful to note the J9/J10/J129 pin).
3. Navigate to the **I-Probe -> QLC -> A128 Expanded** sheet. The J6, QLC variables noted in the **I-Probe -> ADC Expanded** sheet correspond to the QLC260 #.

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4. The highlighted 'probe' columns correspond to Imasonic probes, but are also relevant to some other manufactured probes. The user must consult the datasheets of their own probes for certainty.
5. Cross reference the highlighted 'probe' channels with the highlighted AMP128-18 channel for PST's recommended probe -> QLC adapter path.
6. The highlighted AMP128-18 column can also be cross referenced with the **A128** sheet's # column for a clear signal path of QLC260 -> AMP128 -> J9/J10 ADC256.
7. Open the **I-Probe -> QLC -> A128 Expanded** sheet and sort by #1 for J9/#2 for J10, the green # column is the channel map. Copy the column and paste it as a *.txt file, save the file with a *.map extension and place it into the same folder as the *PhotoSound Data Acquisition Application*.
8. In the Plot tab of the *PhotoSound Data Acquisition Application*, there is a channel map load box. Find the *.map file and load it into the program.
9. Observe channel signals through *PhotoSound Data Acquisition Application*, use the appropriate J9/10 net ADC#_IN# for whichever ADC chip # and channel # the user desires (REMEMBER, the indexing of channels of the ADC chips on the MS Excel sheet is from IN0 – IN31, but the *PhotoSound Data Acquisition Application* indexes from Channel 1 – Channel 32*).*

Note: If the user's probe has different channel paths than the highlighted 'probe' columns in **I-Probe -> QLC -> A128 Expanded**, the user must refer to the probe's datasheet with the **I-Probe -> QLC -> A128 Simple** excel sheet and map the probe to the QLC260 # manually. This is accomplished by sorting QLC260 # and inputting the probe values according to its specifications. The user must then propagate this J6, QLC260 # - Probe map information across all sheets to find a correct channel map. If the user's probe cannot be setup in a logical manner (misalignment of output and ground pins) with the QLC260 adapter, contact a PST representative for customized PCB options.

Custom Configurations

The DAQ256 channel maps are indexed from 1 – 128, which represents 4 32-ch ADCs; however, the DAQ256 has 8 32-ch ADCs, needing 256 indices. This information is consolidated by the *.map file. For standard configurations, the *.map file will automatically generate the 129 – 256 mapping of the latter half of ADC chips. Standard configurations are DAQ256 configurations where both AMP128/SMA128 boards have the exact same probe adapter(s).

In the case of custom configurations, a full 256 index *.map file is needed. A custom configuration can be defined as:

- An extended SMA256 board.
- ADC256 with custom wiring.

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- DAQ256 with different AMP128 probe adapters (i.e. QLC260 + DLM156).

The user must extend the *.map file by concatenating a modified J10's *.map file to the J9's *.map file. The modified J10 *.map file is the regular J10 *.map with 128 added to every index (*.map + 128).

- ADC256wBreakout256SCSI16x16.xlsx
- ADC256wBreakout256GPIOV1.xlsx
- ADC256wBreakout256GPIOV2.xlsx