

# Silicon Photomultiplier (SiPM) High Fill-Factor Arrays

## ArrayJ Series

onsemi's range of J-Series SiPM sensors have been used to create high fill-factor, scalable arrays. The sensors are mounted onto PCB boards with minimal dead space, forming arrays with industry-leading fill factor of up to 90%.

The back of each ArrayJ has either one or more multi-way connectors, or a BGA (ball grid array). These allow access to the fast output\* and standard I/O from each pixel in the array, and a common I/O from the summed substrates of the pixels.

The ArrayJ products with connectors can be used to interface with the user's own readout via a mating connector, or to a onsemi Breakout Board (BOB). The BOBs allow for easy access to the pixel signals and performance evaluation of the arrays.

ArrayJ products with the BGA can be reflow soldered to the user's readout boards, or purchased ready-mounted on a pinned PCB evaluation board for easy testing. A BGA ArrayJ cannot be removed from its PCB evaluation board. This contrasts with an ArrayJ with connectors, as multiple arrays can be evaluated with a single BOB.

### ArrayJ Inputs and Outputs (I/O)

Figure 1 summarizes the array schematic for a portion of an ArrayJ. Each SiPM sensor in the array has three electrical connections: fast output, standard output and common.

The substrates (cathodes) of all sensors are summed together to form the common I/O.

Each individual fast output and standard I/O (anode) are routed to its own output pin.

The pixel-level performance of the sensors in the array can be found in the [J-Series datasheet](#).

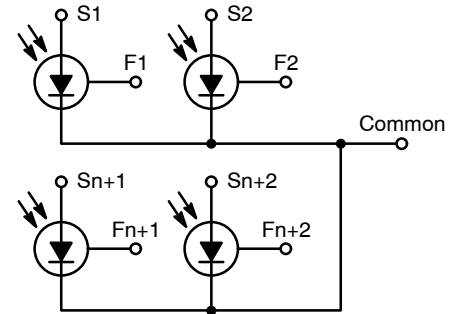
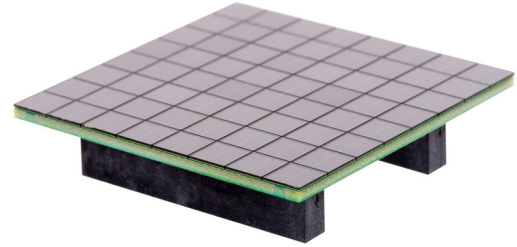


Figure 1. Signal connections at the pixel level on the ArrayJ products.

### ATTENTION!

Great care should be taken when disconnecting the ArrayJ PCBs from the mating connectors, either on one of the BOBs, or the user's own boards.

The board should be gently levered up, working progressively around the board to lever the PCB from the connector a little on all sides, and then repeating the process until the connectors are free from each other.

### Use of Scintillators with the ArrayJ Products

Please consult the [Application Note](#) on the use of scintillators with the TSV arrays.

\* The fast output is not available on the 2x2 array (ARRAYJ-60035-4P).

# ArrayJ Series

## ARRAYJ-60035-64P-PCB (8 X 8 Array of 6 mm Pixels)

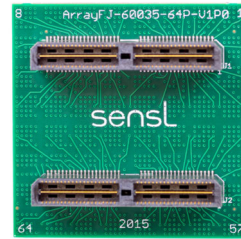
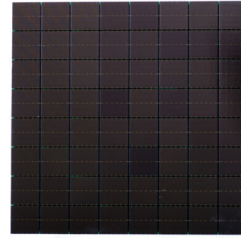
| Array Size | Sensor Type | Readout | Board Size                    | Pixel Pitch | No. Connections | No. Connectors |
|------------|-------------|---------|-------------------------------|-------------|-----------------|----------------|
| 8 x 8      | 60035       | Pixel   | 50.44 x 50.44 mm <sup>2</sup> | 6.33 mm     | 160             | 2 x 80-way     |

The ARRAYJ-60035-64P is comprised of 64 individual 6 mm J-Series sensors arranged in a 8 x 8 array.

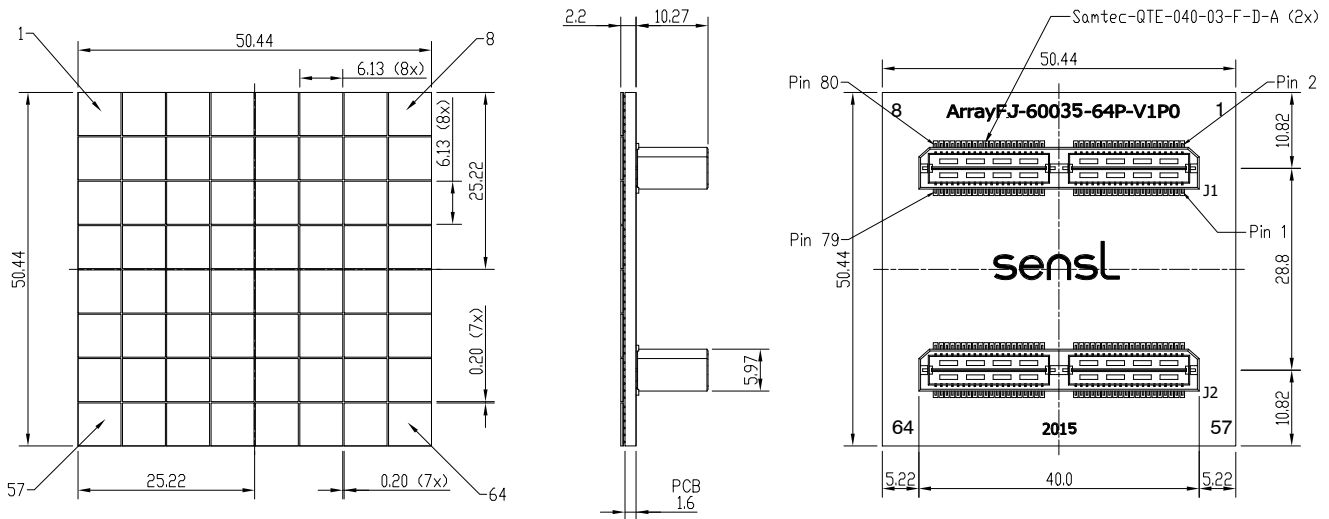
The performance of the individual pixels and details of the bias to apply can be found in the [J-Series datasheet](#).

The connections to each array are provided by two Samtec 80-way connectors, type QTE-040-03-F-D-A. These connectors mate with the Samtec QSE-040-01-F-D-A board-to-board connector and the Samtec EQCD High Speed Cable Assemblies. The 64 SiPM pixels all have substrate connections (cathode) summed to form a common I/O. The 80-way connectors provide connections as follows:

- 64 x fast output
- 64 x standard I/O
- 32 x common I/O
- 16 x shield contacts to the Common



### ARRAYJ-60035-64P Board Drawing



The complete ARRAYJ-60035-64P-PCB CAD is available to [download](#).

# ArrayJ Series

## Connector Schematic for the ARRAYJ-60035-64P-PCB

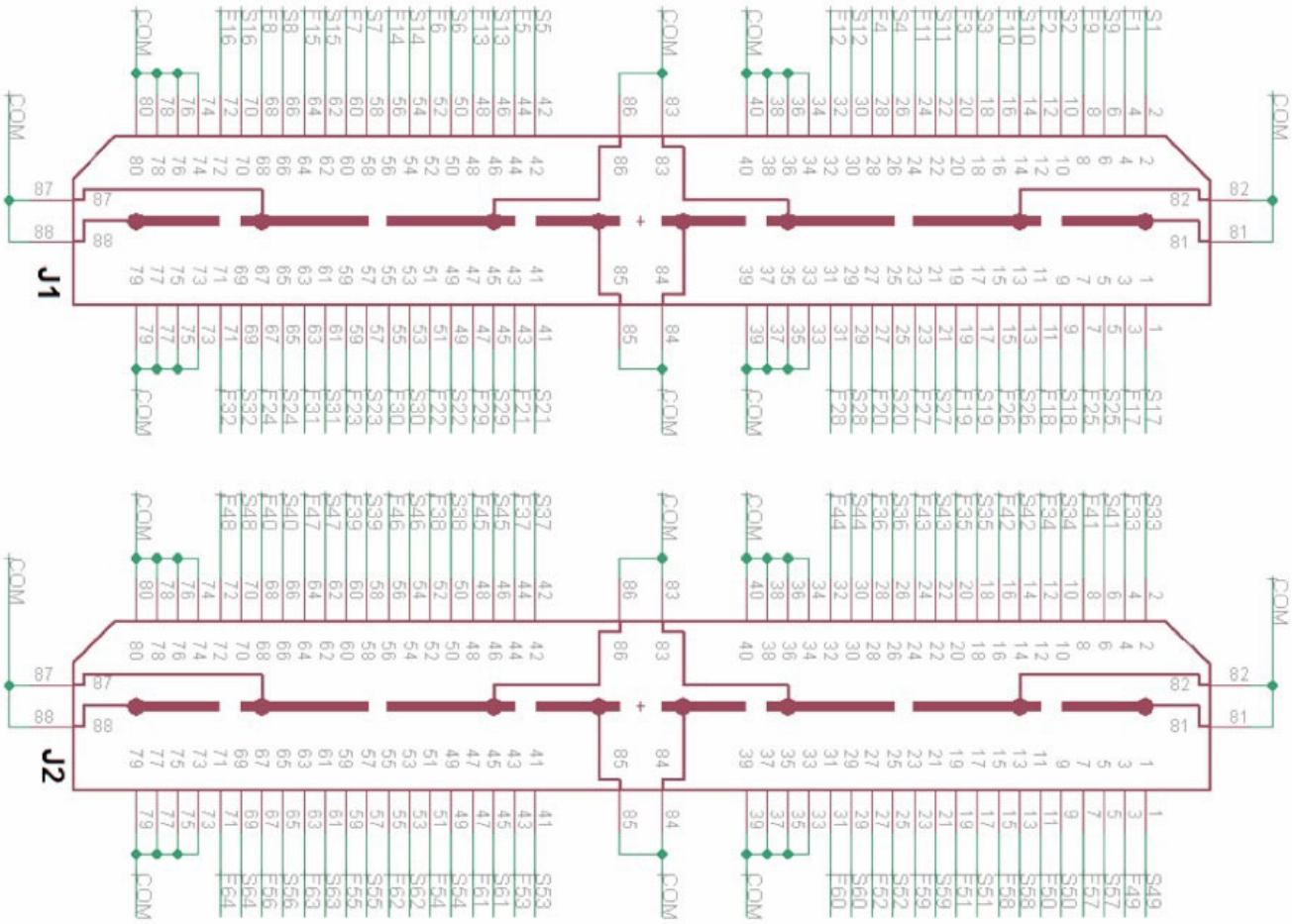


Figure 2. Connector schematic for the ARRAYJ-60035-64P

The connector location and array pixel numbering is indicated on the array schematics on the previous page.

# ArrayJ Series

**Table 1. CONNECTOR PIN-OUTS FOR THE ARRAYJ-60035-64P-PCB**

| J1  |        |     |        | J2  |        |     |        |
|-----|--------|-----|--------|-----|--------|-----|--------|
| PIN | SIGNAL | PIN | SIGNAL | PIN | SIGNAL | PIN | SIGNAL |
| 1   | S17    | 2   | S1     | 1   | S49    | 2   | S33    |
| 3   | F17    | 4   | F1     | 3   | F49    | 4   | F33    |
| 5   | S25    | 6   | S9     | 5   | S57    | 6   | S41    |
| 7   | F25    | 8   | F9     | 7   | F57    | 8   | F41    |
| 9   | S18    | 10  | S2     | 9   | S50    | 10  | S34    |
| 11  | F18    | 12  | F2     | 11  | F50    | 12  | F34    |
| 13  | S26    | 14  | S10    | 13  | S58    | 14  | S42    |
| 15  | F26    | 16  | F10    | 15  | F58    | 16  | F42    |
| 17  | S19    | 18  | S3     | 17  | S51    | 18  | S35    |
| 19  | F19    | 20  | F3     | 19  | F51    | 20  | F35    |
| 21  | S27    | 22  | S11    | 21  | S59    | 22  | S43    |
| 23  | F27    | 24  | F11    | 23  | F59    | 24  | F43    |
| 25  | S20    | 26  | S4     | 25  | S52    | 26  | S36    |
| 27  | F20    | 28  | F4     | 27  | F52    | 28  | F36    |
| 29  | S28    | 30  | S12    | 29  | S60    | 30  | S44    |
| 31  | F28    | 32  | F12    | 31  | F60    | 32  | F44    |
| 33  | CM     | 34  | CM     | 33  | CM     | 34  | CM     |
| 35  | CM     | 36  | CM     | 35  | CM     | 36  | CM     |
| 37  | CM     | 38  | CM     | 37  | CM     | 38  | CM     |
| 39  | CM     | 40  | CM     | 39  | CM     | 40  | CM     |
| 41  | S21    | 42  | S5     | 41  | S53    | 42  | S37    |
| 43  | F21    | 44  | F5     | 43  | F53    | 44  | F37    |
| 45  | S29    | 46  | S13    | 45  | S61    | 46  | S45    |
| 47  | F29    | 48  | F13    | 47  | F61    | 48  | F45    |
| 49  | S22    | 50  | S6     | 49  | S54    | 50  | S38    |
| 51  | F22    | 52  | F6     | 51  | F54    | 52  | F38    |
| 53  | S30    | 54  | S14    | 53  | S62    | 54  | S46    |
| 55  | F30    | 56  | F14    | 55  | F62    | 56  | F46    |
| 57  | S23    | 58  | S7     | 57  | S55    | 58  | S39    |
| 59  | F23    | 60  | F7     | 59  | F55    | 60  | F39    |
| 61  | S31    | 62  | S15    | 61  | S63    | 62  | S47    |
| 63  | F31    | 64  | F15    | 63  | F63    | 64  | F47    |
| 65  | S24    | 66  | S8     | 65  | S56    | 66  | S40    |
| 67  | F24    | 68  | F8     | 67  | F56    | 68  | F40    |
| 69  | S32    | 70  | S16    | 69  | S64    | 70  | S48    |
| 71  | F32    | 72  | F16    | 71  | F64    | 72  | F48    |
| 73  | CM     | 74  | CM     | 73  | CM     | 74  | CM     |
| 75  | CM     | 76  | CM     | 75  | CM     | 76  | CM     |
| 77  | CM     | 78  | CM     | 77  | CM     | 78  | CM     |
| 79  | CM     | 80  | CM     | 79  | CM     | 80  | CM     |

|    |                         |
|----|-------------------------|
| CM | Common I/O              |
| Sn | Standard I/O of pixel n |
| Fn | Fast output of pixel n  |

## ArrayJ Series

### ARRAYX-BOB6-64P (Breakout Board for the ARRAYJ-60035-64P)

The ARRAYX-BOB6-64P is an evaluation board allowing easy access to all the signals of a **onsemi** ARRAYJ-60035-64P, 6 mm 8 x 8 TSV SiPM array.

The Breakout Board features two Samtec 80-way connectors, type QSE-040-01-F-D-A. These connectors mate with the Samtec QTE-040-03-F-D-A board-to-board connector on the array. Since the connectors are keyed, orientating the array on the BOB is straight-forward.

All signals on the array are routed via the mating connectors to header pins. These pins are formed of four 50-way (25 x 2 row) 2.54 mm pitch headers; J3, J4, J5 and J6. Each of the four headers also has 8 pins left unconnected to allow prototyping for evaluation purposes.

The three SMA connectors on the board can be connected via the supplied jumper cable to any of the array header pins and used for accessing signals or supplying bias voltage. Four 7 mm holes are aligned on a 25 mm grid to allow mounting of the board on an optical breadboard.

See Appendices A and B for examples of Breakout Board usage.

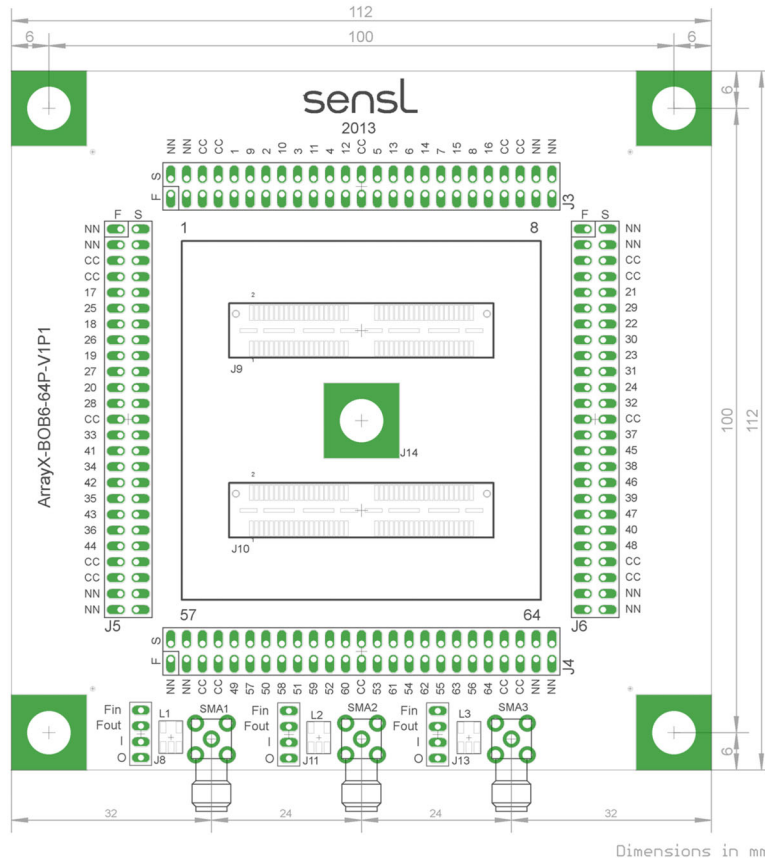
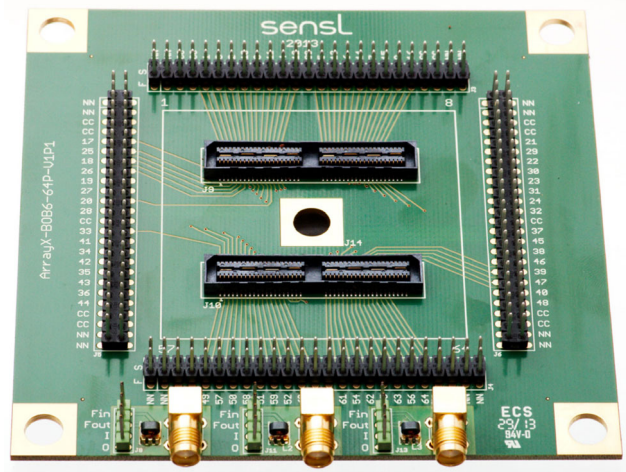


Figure 3. Layout of the ARRAYX-BOB6-64P. The dimensions of the board are 112 mm x 112 mm.

# ArrayJ Series

Table 2. HEADER SIGNALS ON THE ARRAYX-BOB6-64P

| Pin |    | J3  |     | J4  |     | J5  |     | J6  |     |
|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | 2  | NC  | NC  | NC  | NC  | NC  | NC  | NC  | NC  |
| 3   | 4  | NC  | NC  | NC  | NC  | NC  | NC  | NC  | NC  |
| 5   | 6  | CM  | CM  | CM  | CM  | CM  | CM  | CM  | CM  |
| 7   | 8  | CM  | CM  | CM  | CM  | CM  | CM  | CM  | CM  |
| 9   | 10 | F1  | S1  | F49 | S49 | F17 | S17 | F21 | S21 |
| 11  | 12 | F9  | S9  | F57 | S57 | F25 | S25 | F29 | S29 |
| 13  | 14 | F2  | S2  | F50 | S50 | F18 | S18 | F22 | S22 |
| 15  | 16 | F10 | S10 | F58 | S58 | F26 | S26 | F30 | S30 |
| 17  | 18 | F3  | S3  | F51 | S51 | F19 | S19 | F23 | S23 |
| 19  | 20 | F11 | S11 | F59 | S59 | F27 | S27 | F31 | S31 |
| 21  | 22 | F4  | S4  | F52 | S52 | F20 | S20 | F24 | S24 |
| 23  | 24 | F12 | S12 | F60 | S60 | F28 | S28 | F32 | S32 |
| 25  | 26 | CM  | CM  | CM  | CM  | CM  | CM  | CM  | CM  |
| 27  | 28 | F5  | S5  | F53 | S53 | F33 | S33 | F37 | S37 |
| 29  | 30 | F13 | S13 | F61 | S61 | F41 | S41 | F45 | S45 |
| 31  | 32 | F6  | S6  | F54 | S54 | F34 | S34 | F38 | S38 |
| 33  | 34 | F14 | S14 | F62 | S62 | F42 | S42 | F46 | S46 |
| 35  | 36 | F7  | S7  | F55 | S55 | F35 | S35 | F39 | S39 |
| 37  | 38 | F15 | S15 | F63 | S63 | F43 | S43 | F47 | S47 |
| 39  | 40 | F8  | S8  | F56 | S56 | F36 | S36 | F40 | S40 |
| 41  | 42 | F16 | S16 | F64 | S64 | F44 | S44 | F48 | S48 |
| 43  | 44 | CM  | CM  | CM  | CM  | CM  | CM  | CM  | CM  |
| 45  | 46 | CM  | CM  | CM  | CM  | CM  | CM  | CM  | CM  |
| 47  | 48 | NC  | NC  | NC  | NC  | NC  | NC  | NC  | NC  |
| 49  | 50 | NC  | NC  | NC  | NC  | NC  | NC  | NC  | NC  |

|    |                         |
|----|-------------------------|
| NC | Not Connected           |
| CM | Common I/O              |
| Sn | Standard I/O of pixel n |
| Fn | Fast output of pixel n  |

## ArrayJ Series

### ARRAYX-BOB6-64S (Summed Breakout Board for the ARRAYJ-60035-64P)

The ARRAYX-BOB6-64S is an evaluation board allowing easy access to the sum of all of standard pixel signals of a **onsemi** ARRAYJ-60035-64P, 6 mm x 8 TSV array, in addition to all of the individual fast output signals. The Breakout Board features two Samtec 80-way connectors, type QSE-040-01-F-D-A. These connectors mate with the Samtec QTE-040-03-F-D-A board-to-board connector on the array. Since the connectors are keyed, orientating the array on the BOB is straightforward. A schematic of the board is shown in Figure 4 below.

**Fast signals:** All of the fast output signals (Fn) from the array are routed via the mating connectors to header pins. These pins are formed of four 50-way (25 x 2 row) 2.54 mm

pitch headers; J3, J4, J5 and J6. Each of the four headers also has 10 pins that connect to the common cathode (CM) and 8 pins left unconnected (NC) to allow prototyping for evaluation purposes.

Two SMA connectors and Balun transformers are provided with 4-pin headers to allow any fast signal to be connected directly to the SMA or via the transformer using jumper wires.

**Summed output:** A summed output (the anodes of pixels 1 to 64 connected together) is routed to jumper pins (SM) in close proximity to a third SMA connector. Four 7 mm holes are placed on a 25 mm grid to allow mounting of the board on an optical breadboard.

See Appendix C for an example of the use of the summed BOB.

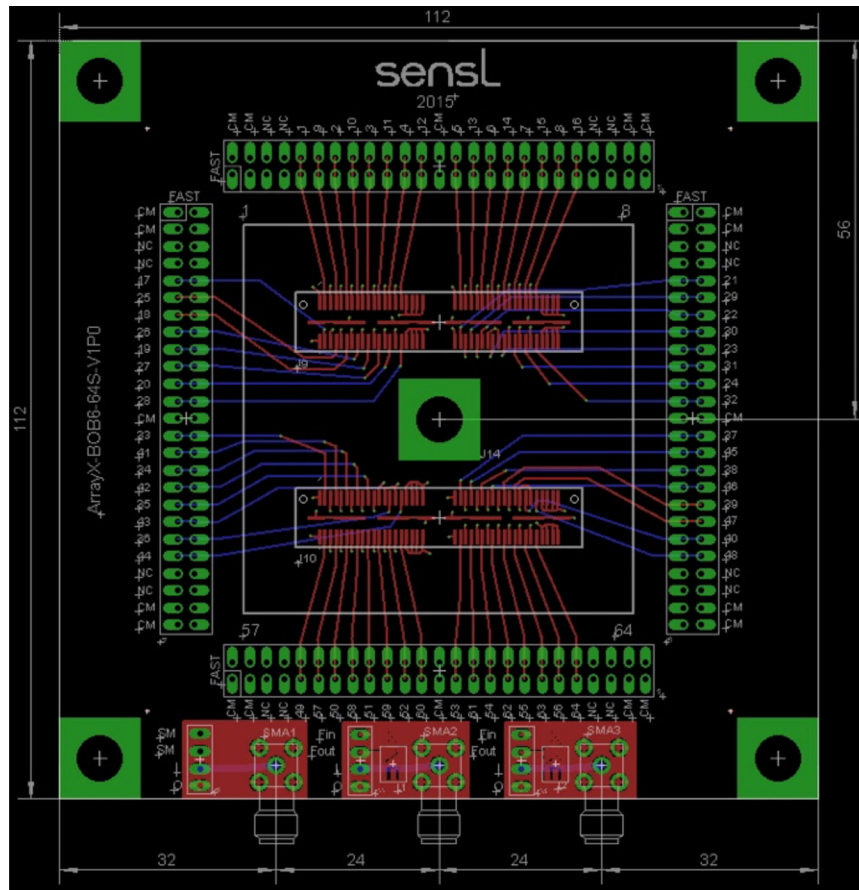


Figure 4. Layout of the ARRAYX-BOB6-64P. The dimensions of the board are 112 mm x 112 mm.

# ArrayJ Series

**Table 3. HEADER SIGNALS ON THE ARRAYX-BOB6-64S**

| Pin |    | J3  |     | J4  |     | J5  |     | J6  |     |
|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | 2  | CM  | CM  | CM  | CM  | CM  | CM  | CM  | CM  |
| 3   | 4  | CM  | CM  | CM  | CM  | CM  | CM  | CM  | CM  |
| 5   | 6  | NC  | NC  | NC  | NC  | NC  | NC  | NC  | NC  |
| 7   | 8  | NC  | NC  | NC  | NC  | NC  | NC  | NC  | NC  |
| 9   | 10 | F1  | F1  | F49 | F49 | F17 | F17 | F21 | F21 |
| 11  | 12 | F9  | F9  | F57 | F57 | F25 | F25 | F29 | F29 |
| 13  | 14 | F2  | F2  | F50 | F50 | F18 | F18 | F22 | F22 |
| 15  | 16 | F10 | F10 | F58 | F58 | F26 | F26 | F30 | F30 |
| 17  | 18 | F3  | F3  | F51 | F51 | F19 | F19 | F23 | F23 |
| 19  | 20 | F11 | F11 | F59 | F59 | F27 | F27 | F31 | F31 |
| 21  | 22 | F4  | F4  | F52 | F52 | F20 | F20 | F24 | F24 |
| 23  | 24 | F12 | F12 | F60 | F60 | F28 | F28 | F32 | F32 |
| 25  | 26 | CM  | CM  | CM  | CM  | CM  | CM  | CM  | CM  |
| 27  | 28 | F5  | F5  | F53 | F53 | F33 | F33 | F37 | F37 |
| 29  | 30 | F13 | F13 | F61 | F61 | F41 | F41 | F45 | F45 |
| 31  | 32 | F6  | F6  | F54 | F54 | F34 | F34 | F38 | F38 |
| 33  | 34 | F14 | F14 | F62 | F62 | F42 | F42 | F46 | F46 |
| 35  | 36 | F7  | F7  | F55 | F55 | F35 | F35 | F39 | F39 |
| 37  | 38 | F15 | F15 | F63 | F63 | F43 | F43 | F47 | F47 |
| 39  | 40 | F8  | F8  | F56 | F56 | F36 | F36 | F40 | F40 |
| 41  | 42 | F16 | F16 | F64 | F64 | F44 | F44 | F48 | F48 |
| 43  | 44 | NC  | NC  | NC  | NC  | NC  | NC  | NC  | NC  |
| 45  | 46 | NC  | NC  | NC  | NC  | NC  | NC  | NC  | NC  |
| 47  | 48 | CM  | CM  | CM  | CM  | CM  | CM  | CM  | CM  |
| 49  | 50 | CM  | CM  | CM  | CM  | CM  | CM  | CM  | CM  |

|                |                        |
|----------------|------------------------|
| NC             | Not Connected          |
| CM             | Common I/O             |
| F <sub>n</sub> | Fast output of pixel n |



# ArrayJ Series

## ARRAYJ-60035-4P-BGA (2 X 2 Array of 6 mm Pixels)

| Array Size | Sensor Type | Readout | Board Size                    | Pixel Pitch | No. Connections | No. Connectors |
|------------|-------------|---------|-------------------------------|-------------|-----------------|----------------|
| 2 x 2      | 60035       | Pixel   | 12.64 x 12.64 mm <sup>2</sup> | 6.33 mm     | 9               | 3 x 3 BGA      |

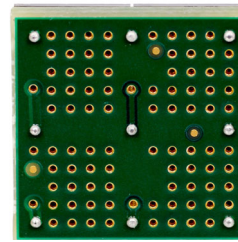
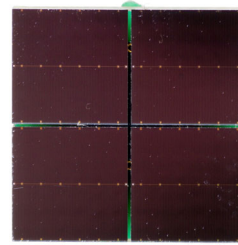
The ARRAYJ-60035-4P is comprised of 4 individual 6 mm J-Series sensors arranged in a 2 x 2 array.

The performance of the individual pixels and details of the bias to apply can be found in the [J-Series datasheet](#).

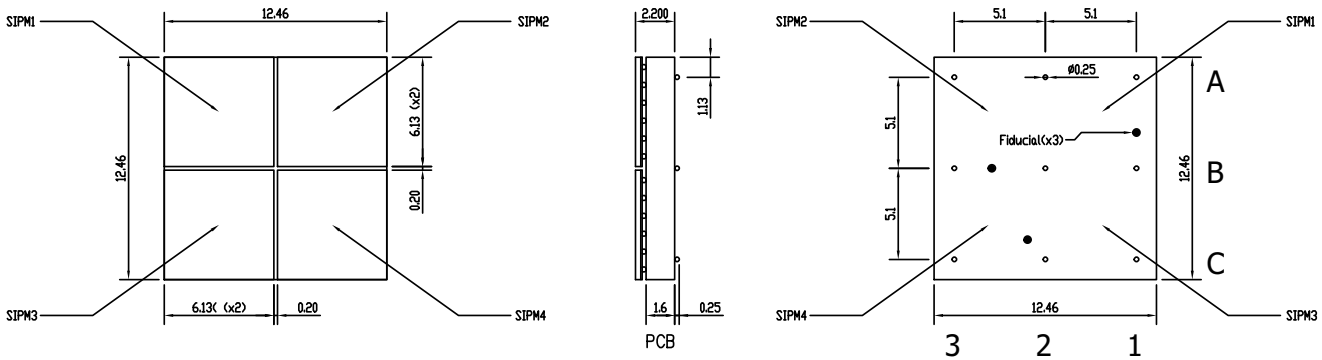
Connections to each sensor are provided by a BGA (ball grid array). The BGA can be reflow soldered onto the user's own readout board.

The 4 SiPM sensors have all substrate connections (cathodes) connected together to form a common I/O. The 3 x 3 BGA provides connections as follows:

- 4 x standard I/O
- 5 x common I/O
- There is NO fast output



### ARRAYJ-60035-4P-BGA Board Dimensions and Pin Location

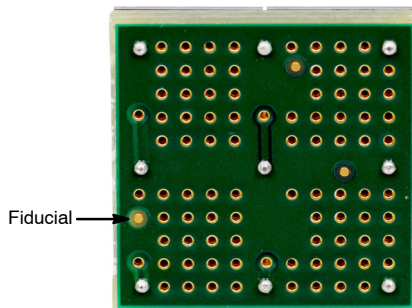


The complete ARRAYJ-60035-4P-BGA CAD and solder footprint is available to [download](#).

## ArrayJ Series

### BGA Connections for the ARRAYJ-60035-4P-BGA

The fiducial is indicated in the image below. It marks the location of both pin A1 and pixel 1.



| Pin. No | Function       |
|---------|----------------|
| A1      | Anode 1        |
| A2      | Anode 2        |
| A3      | Common Cathode |
| B1      | Anode 3        |
| B2      | Anode 4        |
| B3      | Common Cathode |
| C1      | Common Cathode |
| C2      | Common Cathode |
| C3      | Common Cathode |

### ARRAYJ-60035-4P-BGA – Solder Footprint and Reflow Solder Profile

The BGA package is compatible with standard reflow solder processes (J-STD-20) and so is ideal for high-volume manufacturing.

The ARRAYJ-60035-4P-BGA should be mounted according to specified soldering pad patterns, as shown in Figure 5 and in the CAD file which can be downloaded here. The solder pads may be oversized to ease placement of the carrier on the PCB. Consult with your contract manufacturer

for recommendation based upon placement accuracy capability.

Solder paste (**onsemi** recommend using no-clean solder paste) must be evenly applied to each soldering pad to insure proper bonding and positioning of the array. After soldering, allow at least three minutes for the component to cool to room temperature before further operations.

Solder reflow conditions must be in compliance with J-STD-20, table 5.2. This is summarized in Figure 6. The number of passes should not be more than 2.

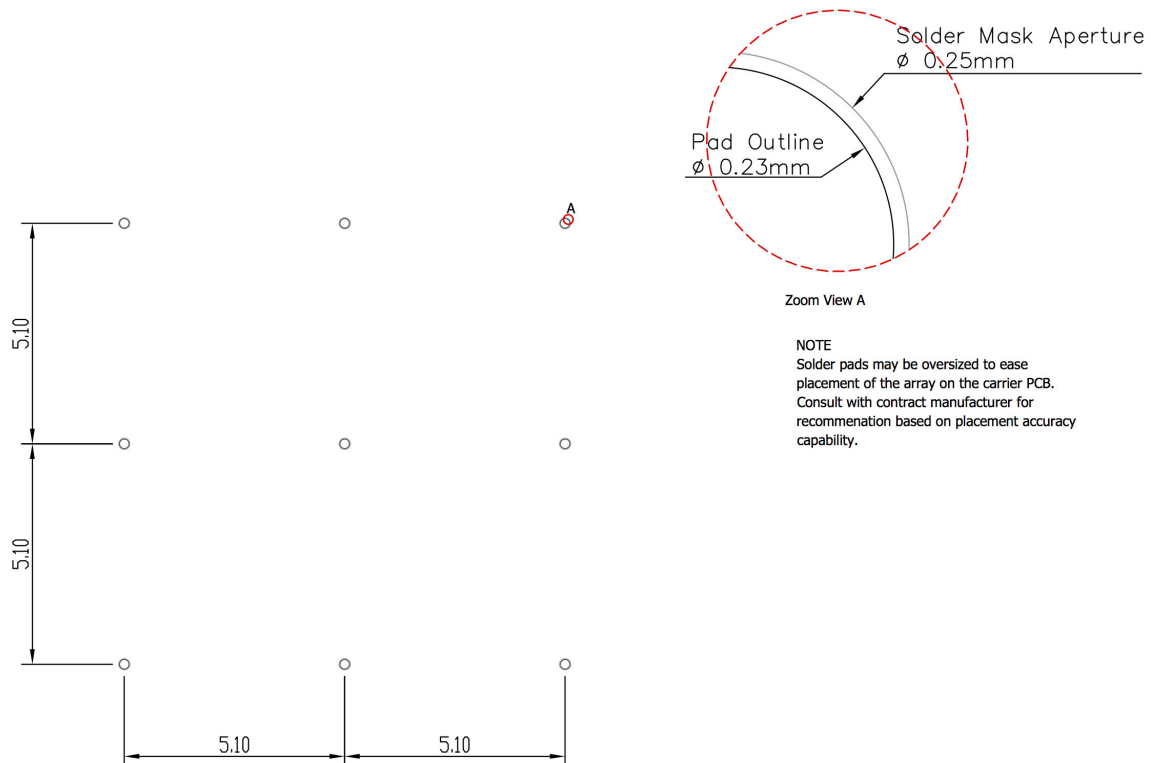


Figure 5. Recommended solder footprint for use with the ARRAYJ-60035-4P-BGA

# ArrayJ Series

## Solder Reflow Profile

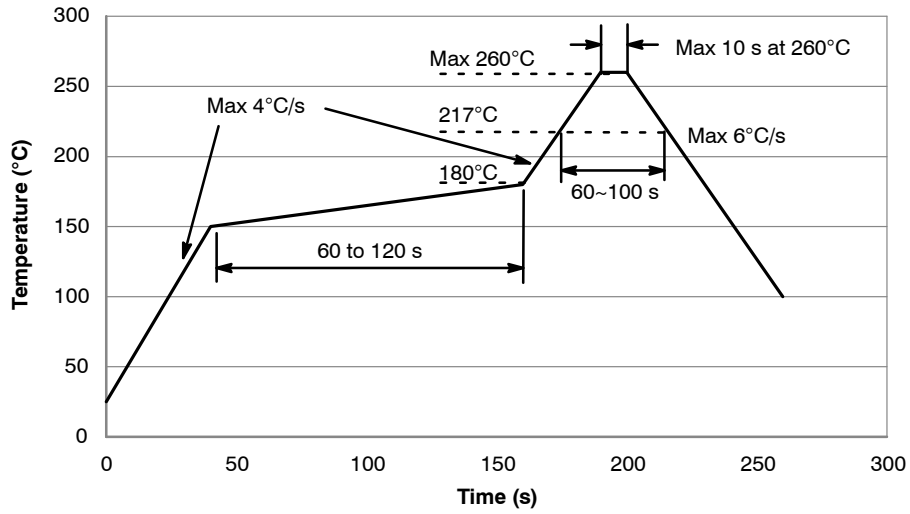


Figure 6. Solder reflow profile. Conditions must be in compliance with J-STD-20, table 5.2.

## ArrayJ Series

### ARRAYJ-60035-4P-PCB (2 x 2 Array of 6 mm Pixels)

The ARRAYJ-60035-4P-PCB is an evaluation board allowing easy access to the signals of a ARRAYJ-60035-4P-BGA via pins.

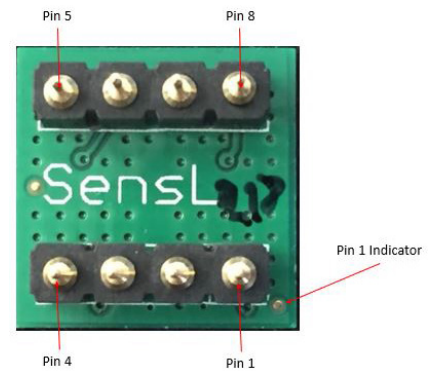
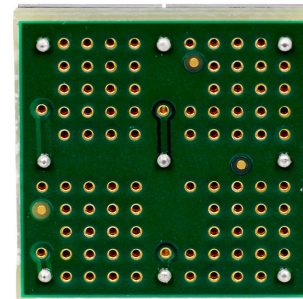
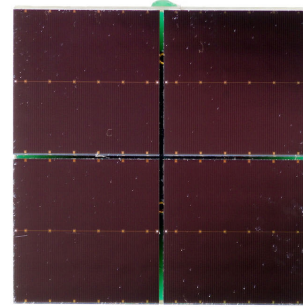
The ARRAYJ-60035-4P-PCB has the array on the front and pins on the back of the PCB. The pins are compatible with a standard 8-pin DIL socket for evaluation purposes. Alternatively, the pins can be directly soldered into through-holes in the user's readout PCB. Four of the pins are connected to the anodes of the individual pixels and the other four pins are connected to the common cathode. An example mating 8-pin DIL socket is the [110-93-308-41-001000 from Mill-Max](http://www.mill-max.com).

The ARRAYJ-60035-4P-PCB does NOT provide access to the fast output.

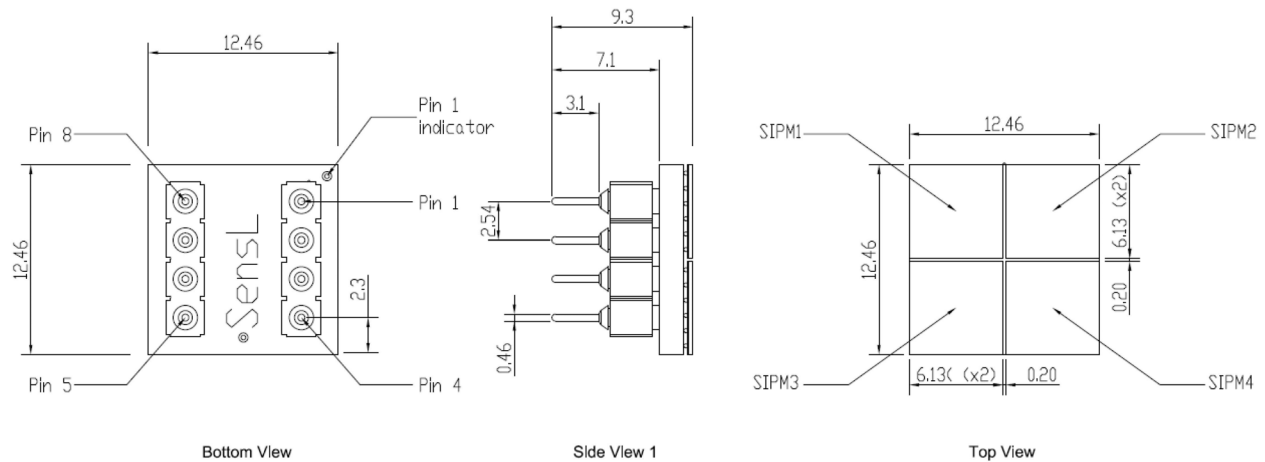
### ARRAYJ-60035-4P-PCB Pin-Outs

| Pin. No | Function       |
|---------|----------------|
| 1       | Anode 1        |
| 2       | Common Cathode |
| 3       | Anode 3        |
| 4       | Common Cathode |
| 5       | Common Cathode |
| 6       | Anode 4        |
| 7       | Common Cathode |
| 8       | Anode 2        |

The location of the pin 1 indicator is shown on the image on the right.



### ARRAYJ-60035-4P-PCB Board Dimensions and Pin Locations



The complete ARRAYJ-60035-4P-PCB CAD is available to [download](#).

## ArrayJ Series

### ARRAYJ-40035-64P-PCB (8 X 8 Array of 4 mm Pixels)

| Array Size | Sensor Type | Readout | Board Size                  | Pixel Pitch | No. Connections | No. Connectors |
|------------|-------------|---------|-----------------------------|-------------|-----------------|----------------|
| 8 x 8      | 40035       | Pixel   | 33.4 x 33.4 mm <sup>2</sup> | 4.2 mm      | 160             | 2 x 80-way     |

The ARRAYJ-40035-64P is comprised of 64 individual 4 mm J-Series sensors arranged in a 8 x 8 array. The performance of the individual pixels and details of the bias to apply can be found in the [J-Series datasheet](#).

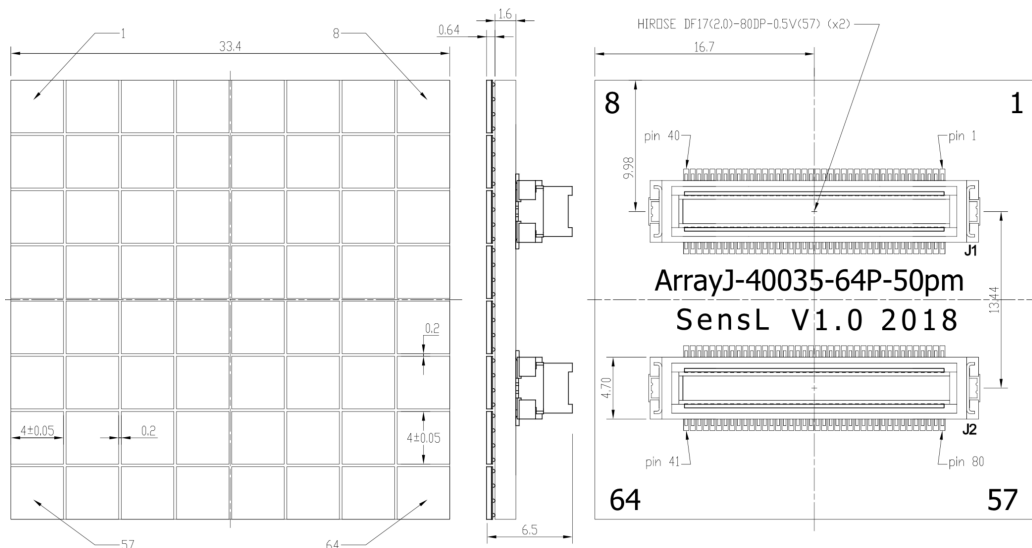
Connections to each sensor are provided by two Hirose 80-way connectors, type DF17(2.0)-80DP-0.5v(57). These connectors mate with the Hirose DF17(2.0)-80DS-0.5v(57) board-to-board connectors. The 64 SiPM sensors have all substrate connections (cathodes) connected together to form a common I/O. The 2 x 80-way connectors provide connections as follows:

- 64 x fast output
- 64 x standard I/O
- 32 x common I/O
- 4 x shield contacts to the Common

#### ARRAYJ-40035-64P Breakout Board

The breakout board for the ARRAYJ-40035-64P-PCB is the same as for the ARRAYJ-300XX-64P-PCB: the ARRAYJ-BOB3-64P. Please see page 25 for details.

#### ARRAYJ-40035-64P-PCB Board Drawing



The complete ARRAYJ-40035-64P-PCB CAD is available to [download](#).

# ArrayJ Series

## Connector Schematics for the ARRAYJ-40035-64P

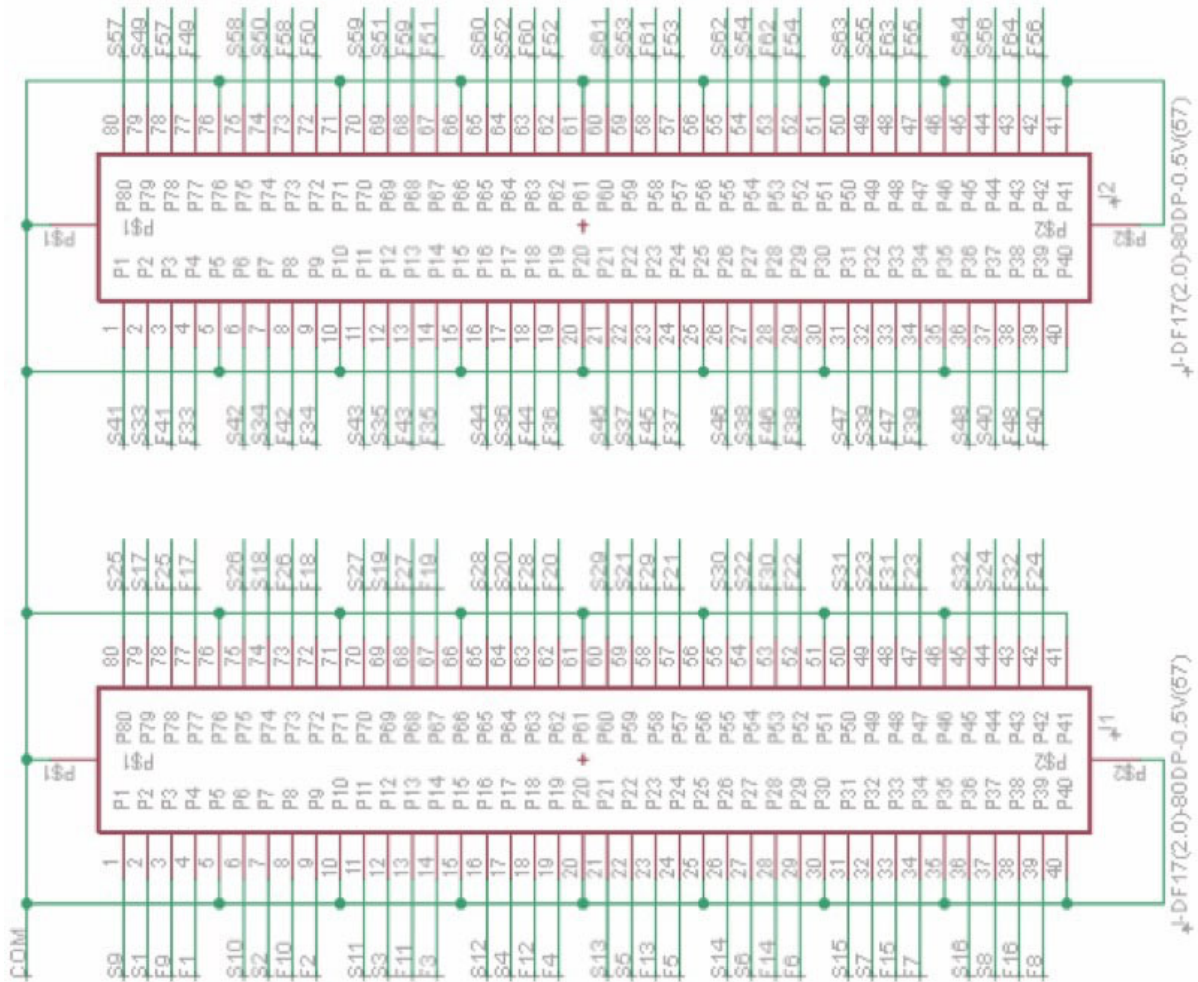


Figure 7. Schematic of the ARRAYJ-40035-64P connectors.

## ArrayJ Series

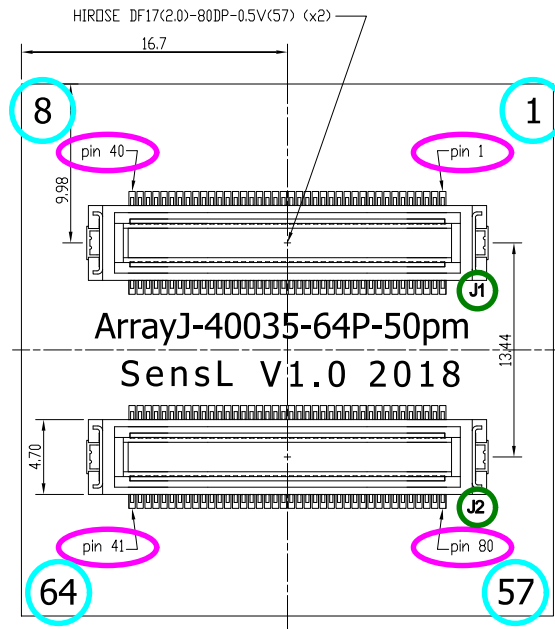


Figure 8. Highlighting the location of the connector, pin and array pixel numbering on the ARRAYJ-40035-64P.

## ArrayJ Series

**Table 4. CONNECTOR PIN-OUTS FOR THE ARRAYJ-40035-64P**

| J1  |        |     |        | J2  |        |     |        |
|-----|--------|-----|--------|-----|--------|-----|--------|
| PIN | SIGNAL | PIN | SIGNAL | PIN | SIGNAL | PIN | SIGNAL |
| 1   | S9     | 2   | S1     | 1   | S41    | 2   | S33    |
| 3   | F9     | 4   | F1     | 3   | F41    | 4   | F33    |
| 5   | CM     | 6   | S10    | 5   | CM     | 6   | S42    |
| 7   | S2     | 8   | F10    | 7   | S34    | 8   | F42    |
| 9   | F2     | 10  | CM     | 9   | F34    | 10  | CM     |
| 11  | S11    | 12  | S3     | 11  | S43    | 12  | S35    |
| 13  | F11    | 14  | F3     | 13  | F43    | 14  | F35    |
| 15  | CM     | 16  | S12    | 15  | CM     | 16  | S44    |
| 17  | S4     | 18  | F12    | 17  | S36    | 18  | F44    |
| 19  | F4     | 20  | CM     | 19  | F36    | 20  | CM     |
| 21  | S13    | 22  | S5     | 21  | S45    | 22  | S37    |
| 23  | F13    | 24  | F5     | 23  | F45    | 24  | F37    |
| 25  | CM     | 26  | S14    | 25  | CM     | 26  | S46    |
| 27  | S6     | 28  | F14    | 27  | S38    | 28  | F46    |
| 29  | F6     | 30  | CM     | 29  | F38    | 30  | CM     |
| 31  | S15    | 32  | S7     | 31  | S47    | 32  | S39    |
| 33  | F15    | 34  | F7     | 33  | F47    | 34  | F39    |
| 35  | CM     | 36  | S16    | 35  | CM     | 36  | S48    |
| 37  | S8     | 38  | F16    | 37  | S40    | 38  | F48    |
| 39  | F8     | 40  | CM     | 39  | F40    | 40  | CM     |
| 41  | CM     | 42  | F24    | 41  | CM     | 42  | F56    |
| 43  | F32    | 44  | S24    | 43  | F64    | 44  | S56    |
| 45  | S32    | 46  | CM     | 45  | S64    | 46  | CM     |
| 47  | F23    | 48  | F31    | 47  | F55    | 48  | F63    |
| 49  | S23    | 50  | S31    | 49  | S55    | 50  | S63    |
| 51  | CM     | 52  | F22    | 51  | CM     | 52  | F54    |
| 53  | F30    | 54  | S22    | 53  | F62    | 54  | S54    |
| 55  | S30    | 56  | CM     | 55  | S62    | 56  | CM     |
| 57  | F21    | 58  | F29    | 57  | F53    | 58  | F61    |
| 59  | S21    | 60  | S29    | 59  | S53    | 60  | S61    |
| 61  | CM     | 62  | F20    | 61  | CM     | 62  | F52    |
| 63  | F28    | 64  | S20    | 63  | F60    | 64  | S52    |
| 65  | S28    | 66  | CM     | 65  | S60    | 66  | CM     |
| 67  | F19    | 68  | F27    | 67  | F51    | 68  | F59    |
| 69  | S19    | 70  | S27    | 69  | S51    | 70  | S59    |
| 71  | CM     | 72  | F18    | 71  | CM     | 72  | F50    |
| 73  | F26    | 74  | S18    | 73  | F58    | 74  | S50    |
| 75  | S26    | 76  | CM     | 75  | S58    | 76  | CM     |
| 77  | F17    | 78  | F25    | 77  | F49    | 78  | F57    |
| 79  | S17    | 80  | S25    | 79  | S49    | 80  | S57    |

|    |                         |
|----|-------------------------|
| CM | Common I/O              |
| Sn | Standard I/O of pixel n |
| Fn | Fast output of pixel n  |



## ArrayJ Series

### ARRAYJ-300XX-16P-PCB (4 X 4 Array of 3 mm Pixels)

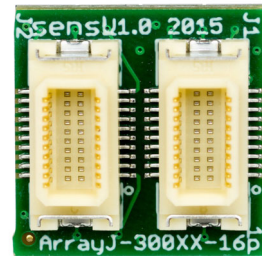
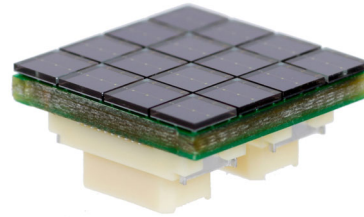
| Array Size | Sensor Type | Readout | Board Size                    | Pixel Pitch | No. Connections | No. Connectors |
|------------|-------------|---------|-------------------------------|-------------|-----------------|----------------|
| 4 x 4      | 30035       | Pixel   | 13.24 x 13.24 mm <sup>2</sup> | 3.36 mm     | 40              | 2 x 20-way     |
|            | 30020       |         |                               |             |                 |                |

The ARRAYJ-300XX-16P is comprised of 16 individual 3 mm J-Series sensors arranged in a 4 x 4 array. There are two types: The ARRAYJ-30035-16P has pixels which are formed of 35  $\mu$ m microcells, and the ARRAYJ-30020-16P has pixels that are formed of 20  $\mu$ m microcells.

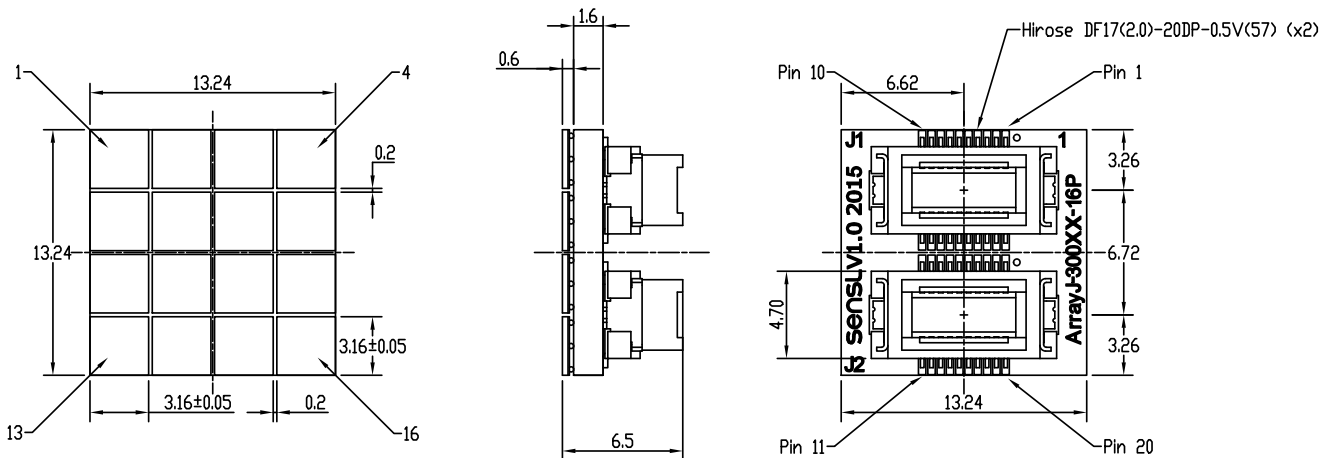
The performance of the individual pixels and details of the bias to apply can be found in the [J-Series datasheet](#).

Connections to each sensor are provided by two 20-way Hirose plug-type board-to-board connectors, DF17(2.0)-20DP-0.5V(57). These connectors mate with the Hirose DF17(3.0)-20DS-0.5V(57). The 16 SiPM pixels have all substrates (cathodes) connected together to form a common I/O. The 20-way connector provides connections as follows:

- 16 x fast output
- 16 x standard I/O
- 8 x common I/O
- 4 x shield contacts to the Common



### ARRAYJ-300XX-16P-PCB Board Drawing



The complete ARRAYJ-300XX-16P-PCB CAD is available to [download](#).

# ArrayJ Series

## Connector Schematic for the ARRAYJ-300XX-16P-PCB

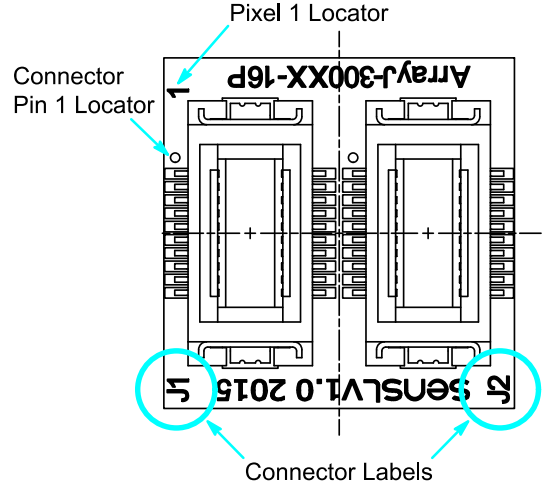
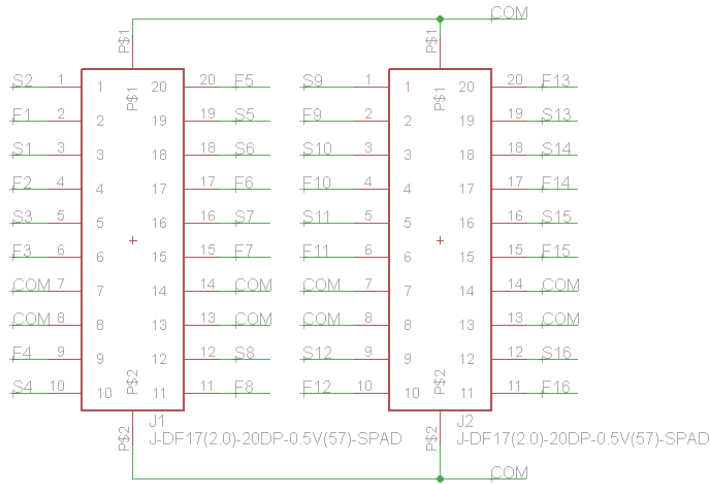


Figure 9. Connector pin-outs for the ARRAYJ-300XX-16P (left), and the location of the connectors (right).

## Connector Schematic for the ARRAYJ-300XX-16P-PCB

The array pixel numbering is indicated on the drawing on the previous page.

| J1  |        |     |        | J2  |        |     |        |
|-----|--------|-----|--------|-----|--------|-----|--------|
| PIN | SIGNAL | PIN | SIGNAL | PIN | SIGNAL | PIN | SIGNAL |
| 1   | S2     | 2   | F1     | 1   | S9     | 2   | F9     |
| 3   | S1     | 4   | F2     | 3   | S10    | 4   | F10    |
| 5   | S3     | 6   | F3     | 5   | S11    | 6   | F11    |
| 7   | CM     | 8   | CM     | 7   | CM     | 8   | CM     |
| 9   | F4     | 10  | S4     | 9   | S12    | 10  | F12    |
| 11  | F8     | 12  | S8     | 11  | F16    | 12  | S16    |
| 13  | CM     | 14  | CM     | 13  | CM     | 14  | CM     |
| 15  | F7     | 16  | S7     | 15  | F15    | 16  | S15    |
| 17  | F6     | 18  | S6     | 17  | F14    | 18  | S14    |
| 19  | S5     | 20  | F5     | 19  | S13    | 20  | F13    |

|    |                         |
|----|-------------------------|
| CM | Common I/O              |
| Sn | Standard I/O of pixel n |
| Fn | Fast output of pixel n  |

## ArrayJ Series

### ARRAYJ-BOB3-16P (ARRAYJ-300XX-16P Breakout Board)

The ARRAYJ-BOB3-16P is an evaluation board allowing easy access to the signals from a **onsemi** ARRAYJ-300XX-16P, 3 mm 4 x 4 SiPM array.

The Breakout Board has two HIROSE 20-way connectors DF17(3.0)-20DS-0.5v(57). These connectors mate with the Samtec DF17(2.0)-20DP-0.5v(57) board-to-board connectors on the array. All signals on the array are routed via the mating connectors to header pins. These pins

are formed by two 20-way (10 x 2 row) 2.54 mm pitch headers.

Three SMA connectors and Balun transformers are provided with 4-pin headers to allow any signal to be connected directly to the SMA or via the transformer using jumper wires. Four 7 mm holes are aligned on a 25 mm grid to allow mounting of the board on an optical breadboard.

See Appendices A and B for examples of Breakout Board usage.

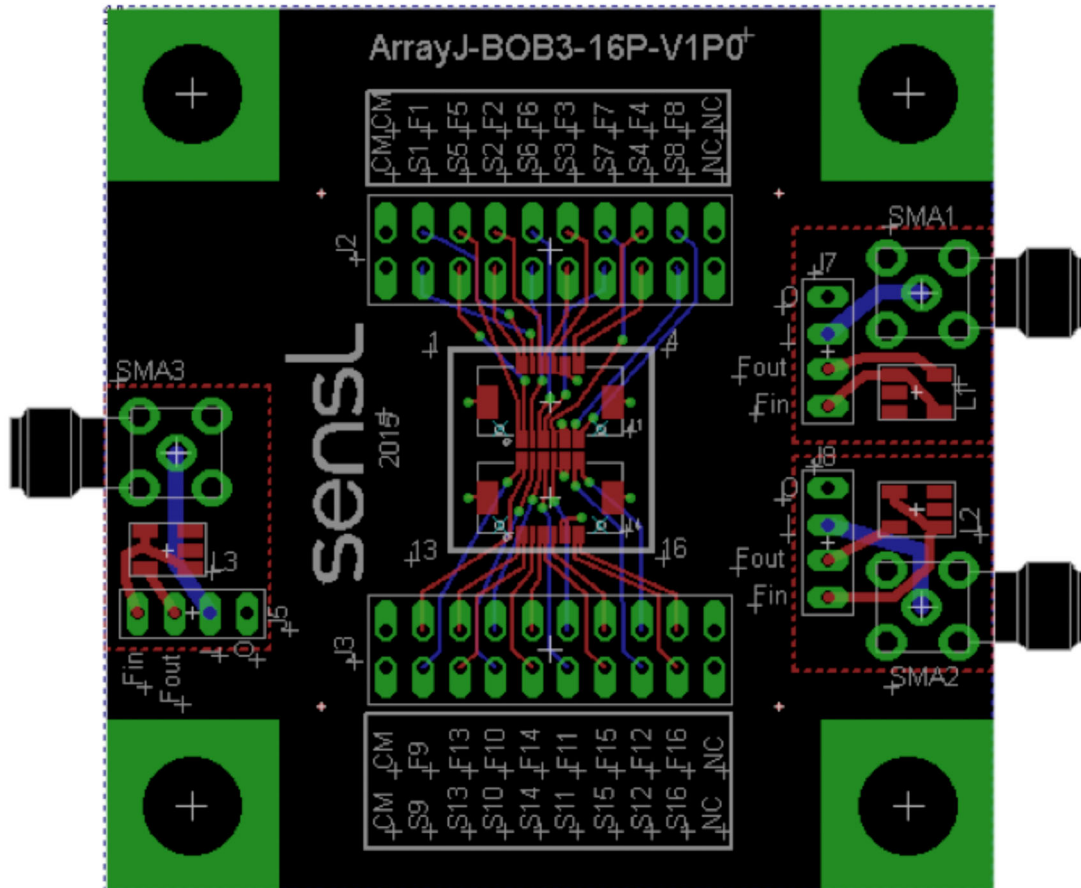


Figure 10. Layout of the ARRAYJ-BOB3-16P. Note that the array corner pixel numbers are shown on the silkscreen of the PCB to ensure correct orientation of the array.

# ArrayJ Series

## Header Signals for the ARRAYX-BOB3-16P

| PIN |    | J2 |     | J3  |     |
|-----|----|----|-----|-----|-----|
| 1   | 2  | CM | CM  | CM  | CM  |
| 3   | 4  | S1 | F1  | S9  | F9  |
| 5   | 6  | S5 | F5  | S13 | F13 |
| 7   | 8  | S2 | F2  | S10 | F10 |
| 9   | 10 | S6 | F6  | S14 | F14 |
| 11  | 12 | S3 | F3  | S11 | F11 |
| 13  | 14 | S7 | F17 | S15 | F15 |
| 15  | 16 | S4 | F4  | S12 | F12 |
| 17  | 18 | S8 | F6  | S16 | F16 |
| 19  | 20 | NC | NC  | NC  | NC  |

|    |                         |
|----|-------------------------|
| NC | Not Connected           |
| CM | Common I/O              |
| Sn | Standard I/O of pixel n |
| Fn | Fast output of pixel n  |

# ArrayJ Series

## ARRAYJ-300XX-64P-PCB (8 X 8 Array of 3 mm Pixels)

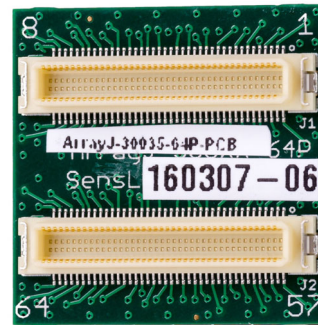
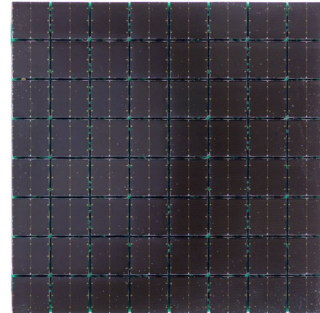
| Array Size | Sensor Type | Readout | Board Size                    | Pixel Pitch | No. Connections | No. Connectors |
|------------|-------------|---------|-------------------------------|-------------|-----------------|----------------|
| 8 x 8      | 30035       | Pixel   | 26.68 x 26.68 mm <sup>2</sup> | 3.36 mm     | 160             | 2 x 80-way     |
|            | 30020       |         |                               |             |                 |                |

The ARRAYJ-300XX-64P is comprised of 64 individual 3 mm J-Series sensors arranged in a 8 x 8 array. There are two types: The ARRAYJ-30035-64P has pixels which are formed of 35 um microcells, and the ARRAYJ-30020-64P has pixels that are formed of 20 um microcells.

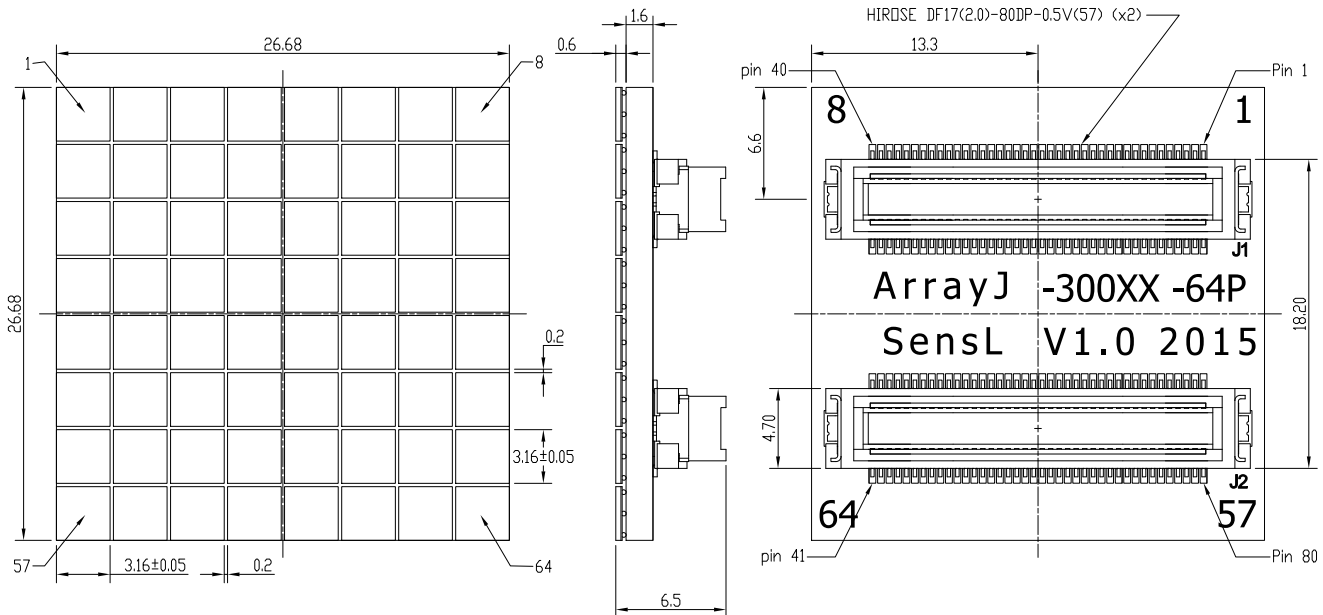
The performance of the individual pixels and details of the bias to apply can be found in the [J-Series datasheet](#).

Connections to each sensor are provided by two Hirose 80-way connectors, type DF17(2.0)-80DP-0.5v(57). These connectors mate with the Hirose DF17(2.0)-80DS-0.5v(57) board-to-board connectors. The 64 SiPM sensors have all substrate connections (cathodes) connected together to form a common I/O. The 2 x 80-way connectors provide connections as follows:

- 64 x fast output
- 64 x standard I/O
- 32 x common I/O
- 4 x shield contacts to the Common



## ARRAYJ-300XX-64P-PCB Board Drawing



The complete ARRAYJ-300XX-64P-PCB CAD is available to [download](#).

# ArrayJ Series

## Connector Schematics for the ARRAYJ-300XX-64P

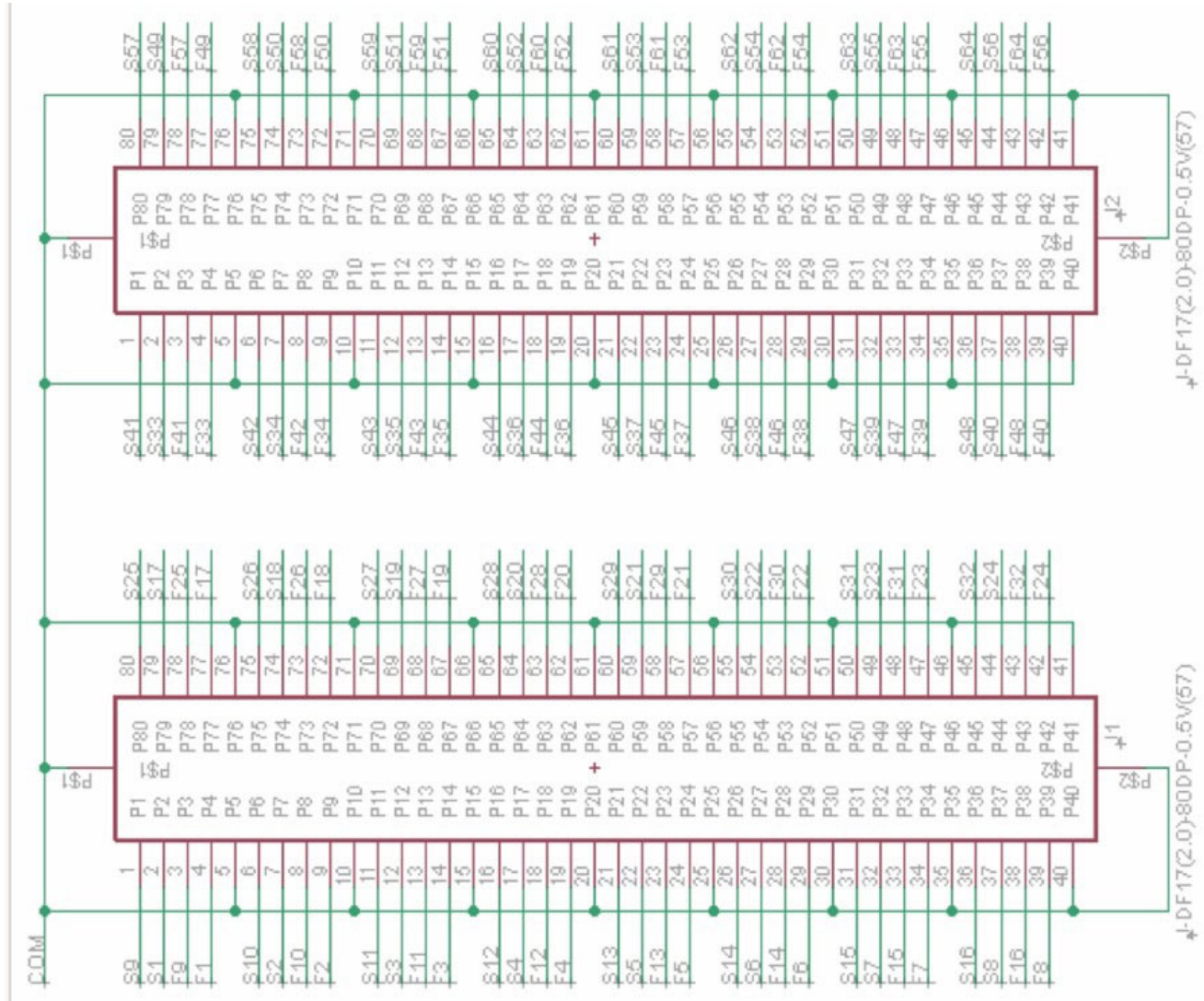


Figure 11. Schematic of the ARRAYJ-300XX-64P connectors.

## ArrayJ Series

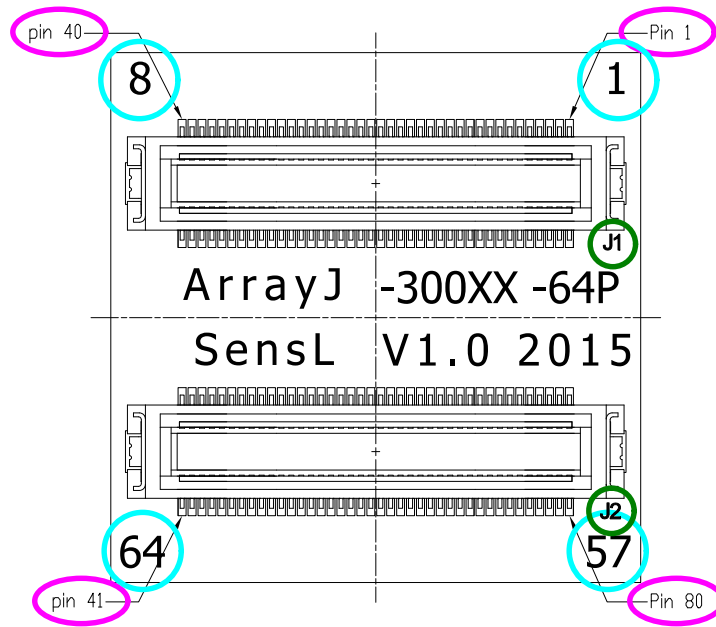


Figure 12. Highlighting the location of the connector, pin and array pixel numbering on the ARRAYJ-300XX-64P.

## ArrayJ Series

**Table 5. CONNECTOR PIN-OUTS FOR THE ARRAYJ-300XX-64P**

| J1  |        |     |        | J2  |        |     |        |
|-----|--------|-----|--------|-----|--------|-----|--------|
| PIN | SIGNAL | PIN | SIGNAL | PIN | SIGNAL | PIN | SIGNAL |
| 1   | S9     | 2   | S1     | 1   | S41    | 2   | S33    |
| 3   | F9     | 4   | F1     | 3   | F41    | 4   | F33    |
| 5   | CM     | 6   | S10    | 5   | CM     | 6   | S42    |
| 7   | S2     | 8   | F10    | 7   | S34    | 8   | F42    |
| 9   | F2     | 10  | CM     | 9   | F34    | 10  | CM     |
| 11  | S11    | 12  | S3     | 11  | S43    | 12  | S35    |
| 13  | F11    | 14  | F3     | 13  | F43    | 14  | F35    |
| 15  | CM     | 16  | S12    | 15  | CM     | 16  | S44    |
| 17  | S4     | 18  | F12    | 17  | S36    | 18  | F44    |
| 19  | F4     | 20  | CM     | 19  | F36    | 20  | CM     |
| 21  | S13    | 22  | S5     | 21  | S45    | 22  | S37    |
| 23  | F13    | 24  | F5     | 23  | F45    | 24  | F37    |
| 25  | CM     | 26  | S14    | 25  | CM     | 26  | S46    |
| 27  | S6     | 28  | F14    | 27  | S38    | 28  | F46    |
| 29  | F6     | 30  | CM     | 29  | F38    | 30  | CM     |
| 31  | S15    | 32  | S7     | 31  | S47    | 32  | S39    |
| 33  | F15    | 34  | F7     | 33  | F47    | 34  | F39    |
| 35  | CM     | 36  | S16    | 35  | CM     | 36  | S48    |
| 37  | S8     | 38  | F16    | 37  | S40    | 38  | F48    |
| 39  | F8     | 40  | CM     | 39  | F40    | 40  | CM     |
| 41  | CM     | 42  | F24    | 41  | CM     | 42  | F56    |
| 43  | F32    | 44  | S24    | 43  | F64    | 44  | S56    |
| 45  | S32    | 46  | CM     | 45  | S64    | 46  | CM     |
| 47  | F23    | 48  | F31    | 47  | F55    | 48  | F63    |
| 49  | S23    | 50  | S31    | 49  | S55    | 50  | S63    |
| 51  | CM     | 52  | F22    | 51  | CM     | 52  | F54    |
| 53  | F30    | 54  | S22    | 53  | F62    | 54  | S54    |
| 55  | S30    | 56  | CM     | 55  | S62    | 56  | CM     |
| 57  | F21    | 58  | F29    | 57  | F53    | 58  | F61    |
| 59  | S21    | 60  | S29    | 59  | S53    | 60  | S61    |
| 61  | CM     | 62  | F20    | 61  | CM     | 62  | F52    |
| 63  | F28    | 64  | S20    | 63  | F60    | 64  | S52    |
| 65  | S28    | 66  | CM     | 65  | S60    | 66  | CM     |
| 67  | F19    | 68  | F27    | 67  | F51    | 68  | F59    |
| 69  | S19    | 70  | S27    | 69  | S51    | 70  | S59    |
| 71  | CM     | 72  | F18    | 71  | CM     | 72  | F50    |
| 73  | F26    | 74  | S18    | 73  | F58    | 74  | S50    |
| 75  | S26    | 76  | CM     | 75  | S58    | 76  | CM     |
| 77  | F17    | 78  | F25    | 77  | F49    | 78  | F57    |
| 79  | S17    | 80  | S25    | 79  | S49    | 80  | S57    |

|    |                         |
|----|-------------------------|
| CM | Common I/O              |
| Sn | Standard I/O of pixel n |
| Fn | Fast output of pixel n  |



## ArrayJ Series

### ARRAYJ-BOB3-64P (ARRAYJ-300XX-64P & ARRAYJ-40035-64P Breakout Board)

The ARRAYJ-BOB3-64P is an evaluation board allowing easy access to the signals from either a **onsemi** ARRAYJ-300XX-64P (3 mm pixel 8 x 8 SiPM array) or a **onsemi** ARRAYJ-40035-64P (4mm pixel, 8 x 8 SiPM array).

The Breakout Board has two Hirose 80-way connectors, type DF17(3.0)-80DS-0.5v(57). These connectors mate with the Hirose DF17(3.0)-80DP-0.5v(57) board-to-board connector on the array.

All signals on the array are routed via the mating connectors to header pins. These pins are formed by four

32-way (16 x 2 row) 2.54 mm pitch headers. Four additional header pin-pairs are provided for connection to the Common.

Three SMA connectors and Balun transformers are provided with 4-pin headers to allow any signal to be connected directly to the SMA or via the transformer using jumper wires. Four 7 mm holes are placed on a 25 mm grid to allow mounting of the board on an optical breadboard.

See Appendices A and B for examples of Breakout Board usage.

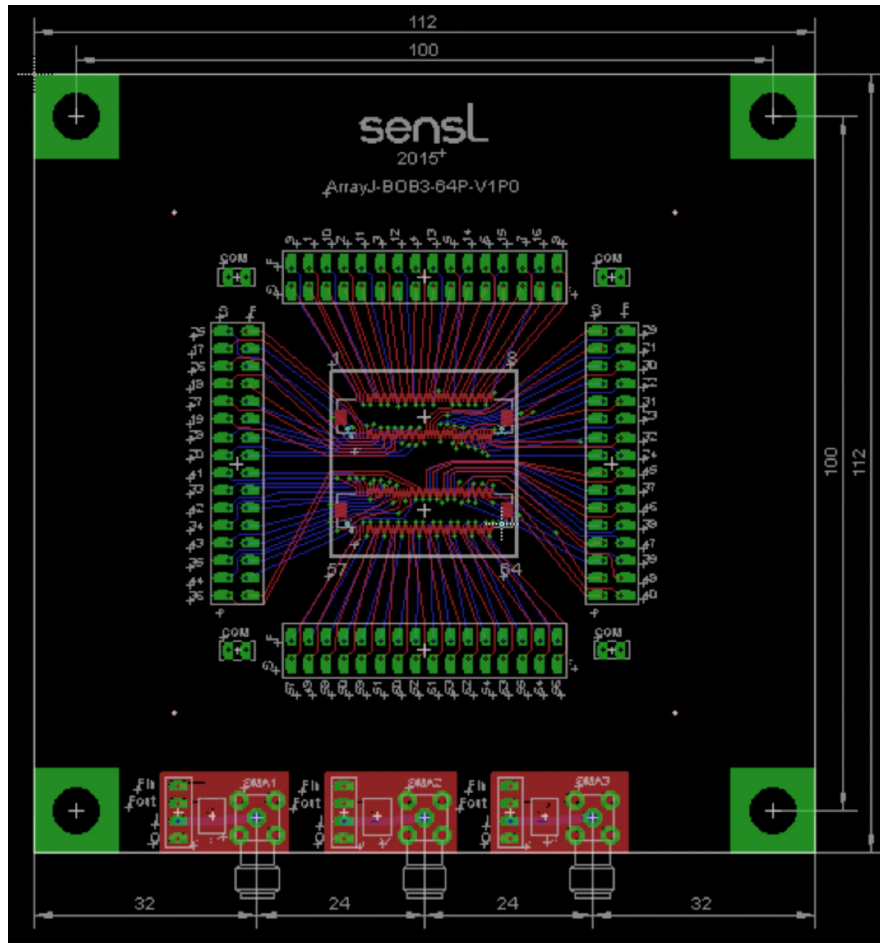


Figure 13. Layout of the ARRAYJ-BOB3-64P. Note that the array corner pixel numbers are shown on the silkscreen of the PCB to ensure correct orientation of the array.

## ArrayJ Series

### Header Signals for the ARRAYJ-BOB3-64P

| PIN |    | J3  |     | J4  |     | J5  |     | J6  |     |
|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | 2  | S9  | F9  | S57 | F57 | S25 | F25 | S29 | F29 |
| 3   | 4  | S1  | F1  | S49 | F49 | S17 | F17 | S21 | F21 |
| 5   | 6  | S10 | F10 | S58 | F58 | S26 | F26 | S30 | F30 |
| 7   | 8  | S2  | F2  | S50 | F50 | S18 | F18 | S22 | F22 |
| 9   | 10 | S11 | F11 | S59 | F59 | S27 | F27 | S31 | F31 |
| 11  | 12 | S3  | F3  | S51 | F51 | S19 | F19 | S23 | F23 |
| 13  | 14 | S12 | F12 | S60 | F60 | S28 | F28 | S32 | F32 |
| 15  | 16 | S4  | F4  | S52 | F52 | S20 | F20 | S24 | F24 |
| 17  | 18 | S13 | F13 | S61 | F61 | S41 | F41 | S45 | F45 |
| 19  | 20 | S5  | F5  | S53 | F53 | S33 | F33 | S37 | F37 |
| 21  | 22 | S14 | F14 | S62 | F62 | S42 | F42 | S46 | F46 |
| 23  | 24 | S6  | F6  | S54 | F54 | S34 | F34 | S38 | F38 |
| 25  | 26 | S15 | F15 | S63 | F63 | S43 | F43 | S47 | F47 |
| 27  | 28 | S7  | F7  | S55 | F55 | S35 | F35 | S39 | F39 |
| 29  | 30 | S16 | F16 | S64 | F64 | S44 | F44 | S48 | F48 |
| 31  | 32 | S8  | F8  | S56 | F56 | S36 | F36 | S40 | F40 |

|    |                         |
|----|-------------------------|
| Sn | Standard I/O of pixel n |
| Fn | Fast output of pixel n  |

## ArrayJ Series

### Biasing and Readout from the Standard Breakout Boards

The purpose of the Breakout Boards is to allow easy access to either standard or fast I/O from individual pixels for testing purposes. It should be stressed that the breakout boards are for evaluation purposes only and do not allow for full readout of all pixels simultaneously.

The various Breakout Boards described in this document have features in common. All pixel fast and standard signals are brought out to headers. The header pins can be interfaced with the SMA connectors with the option of routing the signal via a balun transformer. The common I/O consists of all of the substrate connections summed together. It is not recommended to apply the bias to the common I/O.

The Breakout Boards are each shipped with 3 x shunt jumpers and 6 x 10 cm wire cables (3 x red, 3 x black) with crimp sockets at each end.

All header pins are suitable for use with wire wrapping in addition to the jumpers and crimp socket leads supplied.

The 'NC' signals are unconnected pins that can be used for prototyping.

### SMA Connector

Each Breakout Board has three SMA connectors that can be used for supplying bias voltage and accessing signals. In

addition, each SMA has a balun transformer in close proximity for impedance matching of the fast signals, shown in Figure 13. To interface signals from the array to the SMA connectors, there is a 4-pin header, shown in Figure 12. The pins are labelled; **Fin**, **Fout**, **I** (Inner) and **O** (Outer).

- **Fin** provides the input to the balun transformer.
- **Fout** is the output of the balun transformer.
- **I** provides direct connection to the inner part of the SMA connector.
- **O** provides direct connection to the outer part of the SMA connector.

### Balun Transformer

The Balun transformer (RFMD RFXF9503) allows impedance matching of the fast output signal to the readout electronics. For a customer considering their own design, the Balun is not required if the readout amplifiers are placed in close proximity to the sensor pixels of the array.

For optimized timing performance, the impedance matching and signal propagation from the SiPM sensor to the readout electronics must be carefully considered.

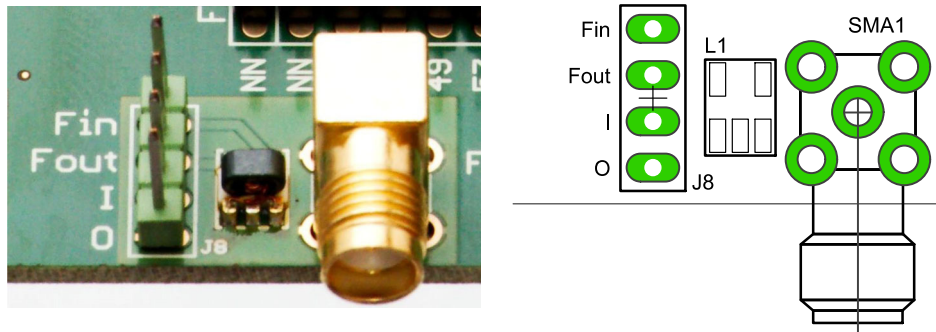
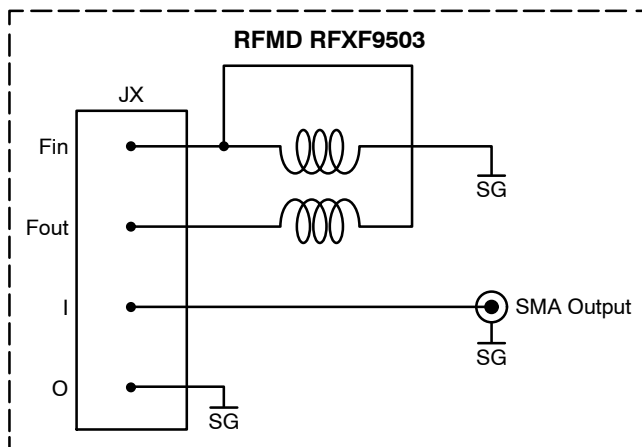


Figure 14. (right) photo and (left) schematic of the BOB SMA, balun transformer and 4-pin header arrangement.

## ArrayJ Series



SG = Local signal ground  
Each SMT/Balun/4 Way Header circuits has its own local signal ground

**Figure 15. Schematic of the 4-pin header and balun transformer**

### EMI Considerations

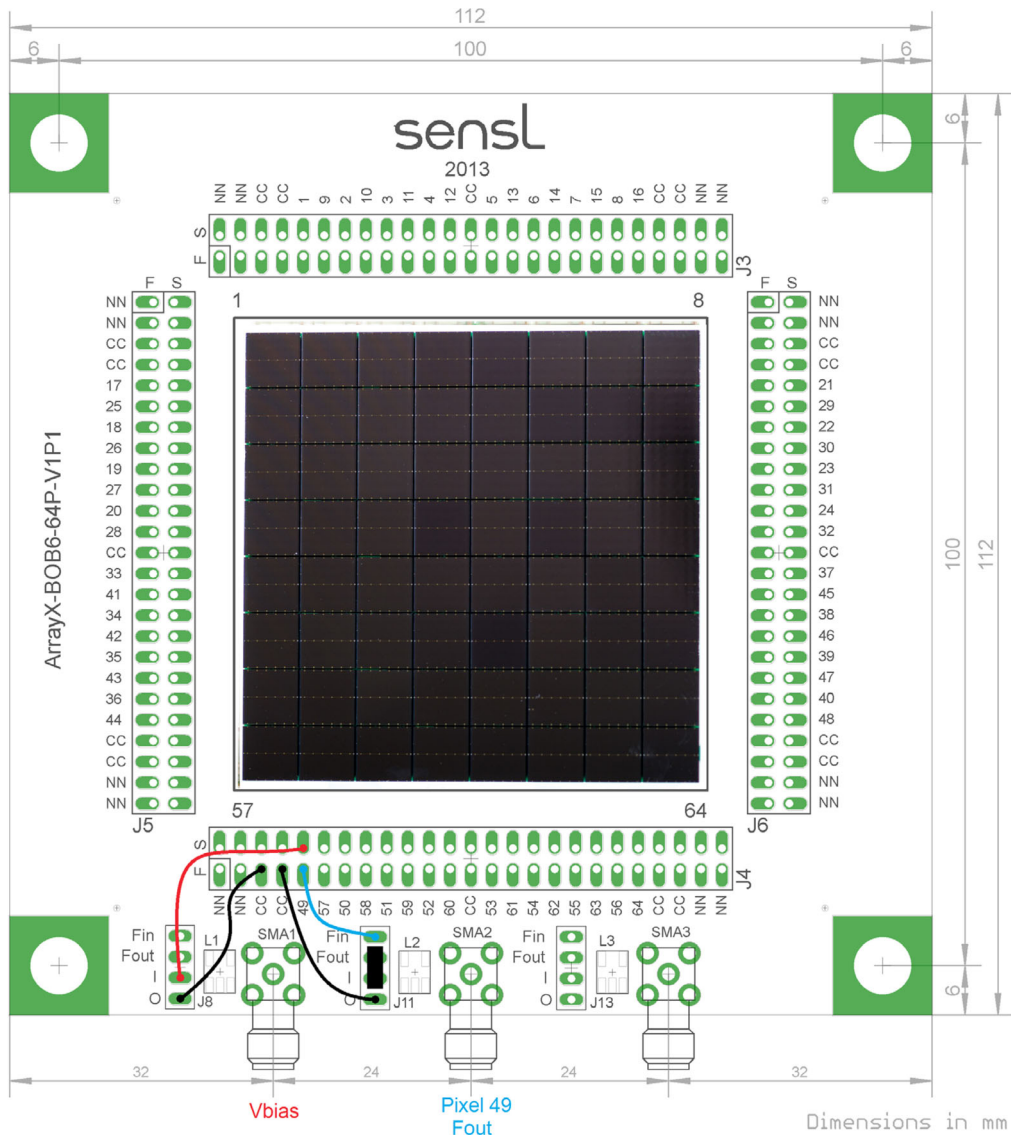
It has been shown that the EMI (Electromagnetic Interference) can be picked up on the unshielded wires on the BOB. It is recommended that customers who experience excessive EMI seek to reduce the EMI in their lab, ideally at the EMI source. If this is not possible then improved shielding should be used. In all cases, testing of the SiPM sensor should be performed in total darkness.

For a system design, it is recommended that the customer consider shielding of all lines. The readout requirements for a SiPM are similar to that of a PMT and similar care should be taken with both sensor types. In comparison to an APD which has significantly lower gain than a SiPM, the SiPM will provide much improved resistance to EMI due to the higher gain of the SiPM sensor.

## ArrayJ Series

### APPENDIX A – EXAMPLE OF USING THE BREAKOUT BOARD TO READOUT FAST SIGNALS

The Figure 16 shows the ARRAYX–BOB6–64P set up for readout of fast signals from pixel 49



**Figure 16. Example of an ARRAYJ–60035–64P connected to an ARRAYX–BOB6–64P for the readout of the fast signal from pixel 49.**

Here, SMA1 is used for supplying Vbias and SMA2 for reading out the fast output from pixel 49. In this example an ARRAYJ–60035–64P is assumed and so the “S” (standard I/O) is the anode.

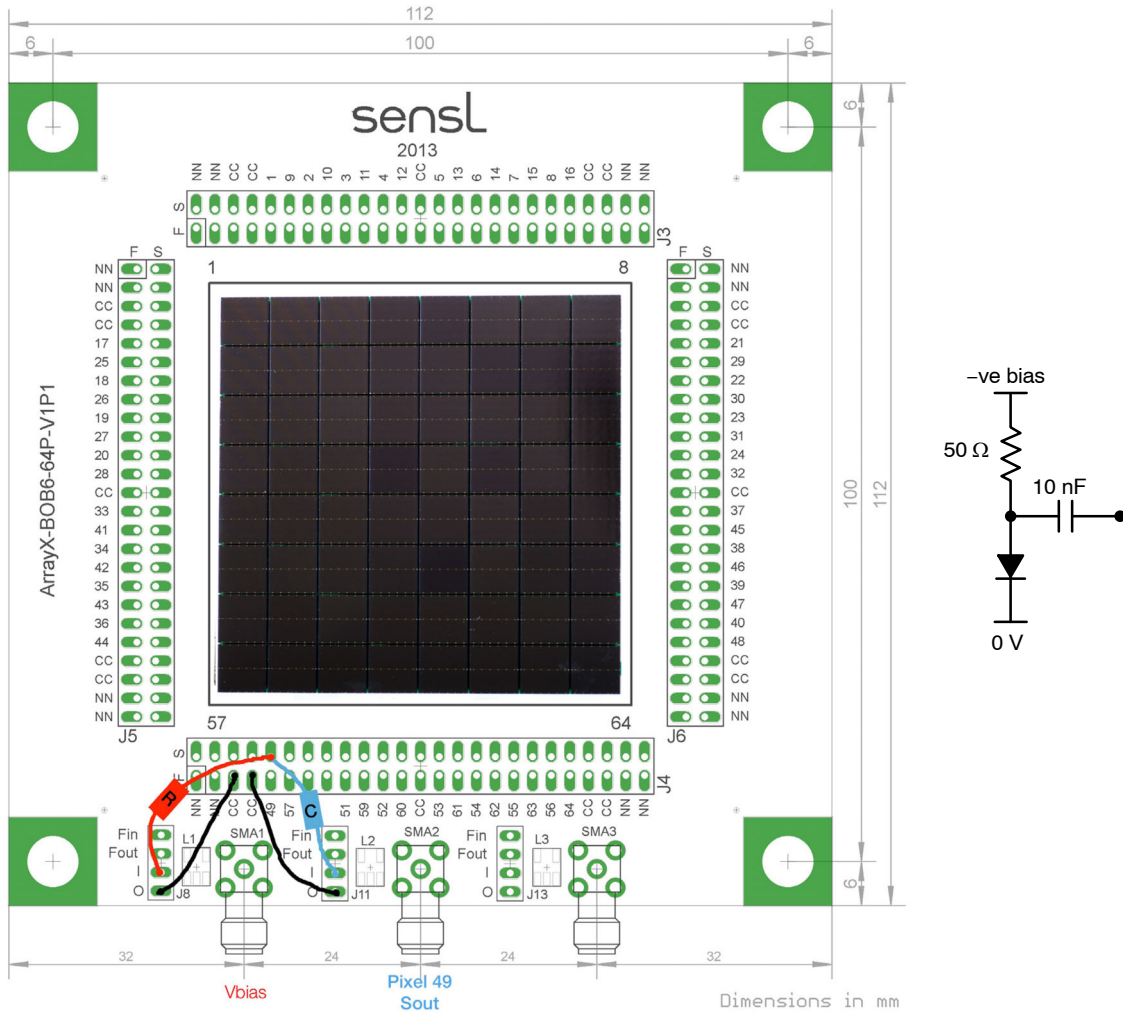
To bias the array, the inner (“I”) of SMA1 is connected to the S49 header pin. The cathode is common to all pixels and is connected via a “C” pin on the header to the outer (“O”) of SMA1. Refer to Figure 1 for signal connections for the J-Series array. Vbias is then applied to SMA1, which for an ArrayJ sensors has a negative polarity with respect to the common cathode.

To access the fast output from pixel 49, the F49 header pin is then connected to the Fin of SMA2. This is the input to the balun transformer for impedance matching of the fast signals. Fout (the output of the balun transformer) is then connected via a shunt jumper to the inner (“I”) of SMA2, with the outer (“O”) again connected to the common cathode (“C”). The schematic of the balun transformer is shown in Figure 15. The fast output from SMA2 will need amplification if the signal amplitudes are small.

## ArrayJ Series

### APPENDIX B – EXAMPLE OF USING THE BREAKOUT BOARD TO READOUT STANDARD SIGNALS

The Figure 17 shows the ARRAYX–BOB6–64P set up for readout of standard signals (anode–cathode) from pixel 49.



**Figure 17. Example of an ARRAYJ–60035–64P connected to an ARRAYX–BOB6–64P for the readout of the fast signal from pixel 49.**

Here, SMA 1 is used for supplying Vbias and SMA2 for reading out the standard output from pixel 49. In this example an ARRAYJ–60035–64P is assumed and so the “S” (standard I/O) is the anode.

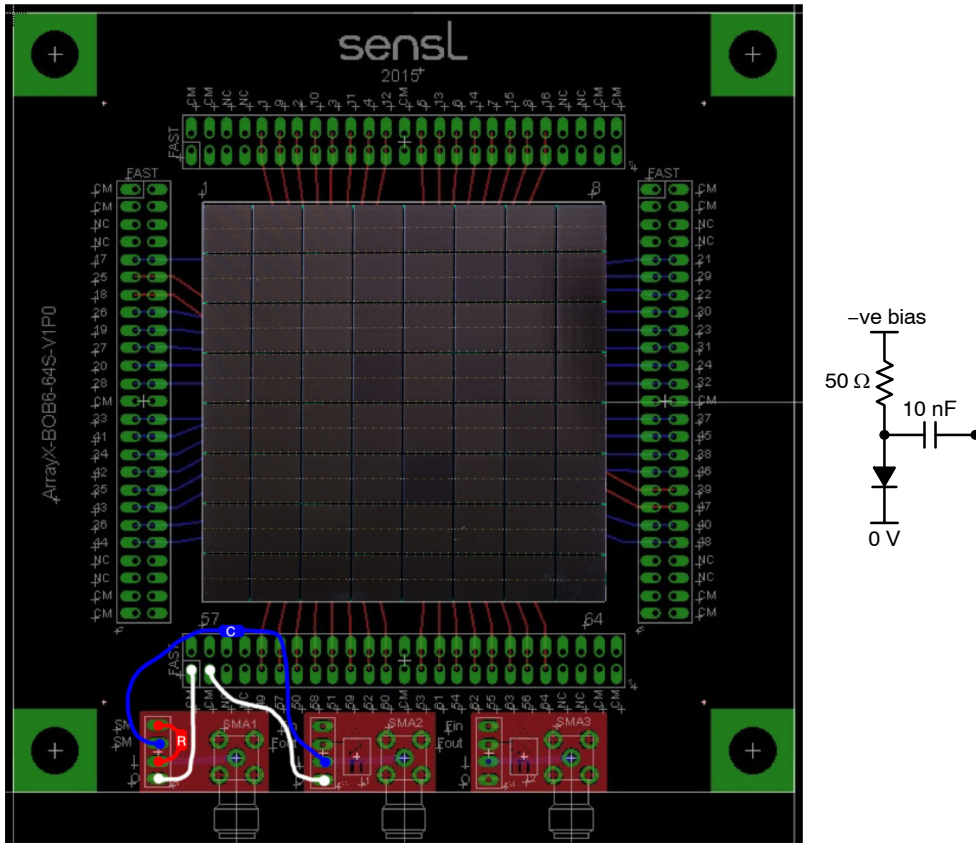
To bias the array, the inner (“I”) of SMA1 is connected to the S49 (anode) header pin via a load resistor of 50 Ω. The cathode is common to all pixels and is connected via a “C” pin on the header to the outer (“O”) of SMA1. Vbias is then applied to SMA1, which for an ArrayJ sensors has a negative polarity with respect to the common cathode.

To access the standard output, the S49 header pin is then connected to the inner (“I”) of SMA2 via a decoupling capacitor of 10nF. The outer (“O”) of SMA 2 is again connected to the common cathode (“C”). The standard signal is then available from SMA2.

## ArrayJ Series

### APPENDIX C – EXAMPLE OF USING THE SUMMED BREAKOUT BOARD

The Figure 18 shows the ARRAYX-BOB6-64S set up for readout of all of the pixels summed together.



**Figure 18. Example of an ARRAYJ-60035-64P connected to an ARRAYX-BOB6-64S for the summed readout of all of the pixels.**

SMA 1 is used for supplying  $V_{bias}$  and SMA2 for reading out the summed standard output from all pixels in the ARRAYJ-60035-64P.

To bias the array, the inner (“I”) of SMA1 is connected to the SM (summed anode) pin on the same header, via a load resistor of  $50\ \Omega$ . The cathode is also common to all pixels and is connected via a “CM” pin to the outer (“O”) of SMA1.

$V_{bias}$  is then applied to SMA1, which for an ArrayJ has a negative polarity with respect to the common.

To access the summed standard output, the second SM header pin is then connected to the inner (“I”) of SMA2 via a decoupling capacitor of  $10\text{ nF}$ . The outer (“O”) of SMA2 is again connected to the common cathode (“CM”). The summed signal is then available from SMA2.

## ArrayJ Series

### ORDERING INFORMATION

| Product Code   | Microcell Size<br>(Total Number per Pixel)                                       | Array Size | I/O Interface |
|--|--|------------|---------------|
| <b>6 mm Sensor Arrays</b>                                |  |            |               |
| ARRAYJ-60035-4P-BGA                                      | 35 $\mu$ m<br>(22,292 microcells)  | 2 x 2      | BGA           |
| ARRAYJ-60035-64P-PCB                                     |  | 8 x 8      | Connector     |
| <b>4 mm Sensor Arrays</b>                                |  |            |               |
| ARRAYJ-40035-64P-PCB                                     | 35 $\mu$ m<br>(9,260 microcells)   | 8 x 8      | Connector     |
| <b>3 mm Sensor Arrays</b>                                |  |            |               |
| ARRAYJ-30035-16P-PCB                                     | 35 $\mu$ m<br>(5,676 microcells)   | 4 x 4      | Connector     |
| ARRAYJ-30035-64P-PCB                                     |  | 8 x 8      | Connector     |
| ARRAYJ-30020-16P-PCB                                     | 20 $\mu$ m<br>(14,850 microcells)  | 4 x 4      | Connector     |
| ARRAYJ-30020-64P-PCB                                     |  | 8 x 8      | Connector     |
| <b>Optional Breakout Boards</b>                          |  |            |               |
| ARRAYX-BOB6-64P-GEVK                                     | Breakout board for use with the ARRAYJ-60035-64P-PCB                             |            |               |
| ARRAYJ-BOB3-16P-GEVK                                     | Breakout board for use with the ARRAYJ-300XX-16P-PCB                             |            |               |
| ARRAYJ-BOB3-64P-GEVK                                     | Breakout board for use with the ARRAYJ-300XX-64P-PCB & ARRAYJ-40035-64P-PCB      |            |               |
| <b>Optional Summed Breakout Boards</b>                   |  |            |               |
| ARRAYX-BOB6-64S-GEVK                                     | Summed breakout board for use with the ARRAYJ-60035-64P-PCB                      |            |               |
| <b>Evaluation Board with ARRAYJ Permanently Attached</b> |  |            |               |
| ARRAYJ-60035-4P-PCB                                      | Evaluation board with a permanently attached ARRAYJ-60035-4P-BGA and output pins |            |               |



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