**Product Description**

The QPI-12 EMI filter is specifically designed to attenuate conducted common-mode (CM) and differential-mode (DM) noise of Vicor VI Chip® products, such as the PRM™, VTM™ and BCM® converters, to comply with the CISPR22 standard requirements for conducted noise measurements. The filter is designed to operate up to 80VDC, 100VDC surge, and supports 7A loads up to 85°C (T_A) without de-rating.

Designed for the telecom bus range, the VI Chip EMI filter supports the PICMG® 3.0 specification for filtering system boards to the EN55022 Class B limits.

**Features & Benefits**

- 45dB CM attenuation at 1MHz (50Ω)
- 75dB DM attenuation at 1MHz (50Ω)
- 80V_{DC} (max input)
- 100V_{DC} surge 100ms
- 1,500V_{DC} hipot hold off to shield plane
- 7A rating
- Low-profile LGA package
- ~1/2in² area
- −40 to +125°C PCB temperature (see Figure 6)
- Efficiency >99%
- TÜV Certified

**Applications**

- VI Chip Input EMI Filter
- Telecom and ATCA boards

**Package Information**

- 12.9 x 25.3 x 5.0mm, lidded SiP (System-in-Package)
- 12.4 x 24.9 x 4.09mm, open-frame

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Typical Applications

Typical QPI-12 application schematic with Vicor PRM and VTM modules [a]

Typical QPI-12 application schematic with Vicor BCM module [a]

[a] CB1 capacitor, referenced in all schematics, is a 47µF electrolytic; United Chemi-Con EMVE101ARA470MKE0S or equivalent.

CY1 to CY4, referenced in all schematics, are 4.7nF high-voltage safety capacitors; Vishay VY1472M63Y5UQ63V0 or equivalent.
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Order Information

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPI-12LZ</td>
<td>QPI-12 LGA package, RoHS compliant</td>
</tr>
<tr>
<td>QPI-12LZ-01</td>
<td>QPI-12 LGA package, RoHS compliant, open-frame package</td>
</tr>
</tbody>
</table>

**Evaluation Board**

<table>
<thead>
<tr>
<th>Evaluation Board</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPI-12-CB1</td>
<td>A QPI-12LZ mounted on a carrier board that can hold either a standalone BCM® or a paired PRM™/VTM™ evaluation board available from Vicor.</td>
</tr>
</tbody>
</table>

QPI-12LZ is a non-hermetically sealed package. Please read the “Post-Solder Cleaning” section on page 13.

**Absolute Maximum Ratings**

Exceeding these parameters may result in permanent damage to the product.

<table>
<thead>
<tr>
<th>Name</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage, BUS+ to BUS–, Continuous</td>
<td>–80 to 80VDC</td>
</tr>
<tr>
<td>Input Voltage, BUS+ to BUS–, 100ms Transient</td>
<td>–100 to 100VDC</td>
</tr>
<tr>
<td>BUS+/ BUS– to Shield Pads, Hi-pot</td>
<td>–1500 to 1500VDC</td>
</tr>
<tr>
<td>Input to Output Current, Continuous @ 25°C (TA)</td>
<td>7A&lt;sub&gt;DC&lt;/sub&gt;</td>
</tr>
<tr>
<td>Power Dissipation, @ 85°C (TA), 7A [c]</td>
<td>1.85W</td>
</tr>
<tr>
<td>Operating Temperature - TA</td>
<td>–40 to 125°C</td>
</tr>
<tr>
<td>Thermal Resistance [k] - θ&lt;sub&gt;JB,JA&lt;/sub&gt;, using PCB layout in Figure 22</td>
<td>30°C/W</td>
</tr>
<tr>
<td>Thermal Resistance [k] - θ&lt;sub&gt;JB,PCB&lt;/sub&gt;</td>
<td>18°C/W</td>
</tr>
<tr>
<td>Storage Temperature, JEDEC Standard J-STD-033B</td>
<td>–55 to 125°C</td>
</tr>
<tr>
<td>Reflow Temperature, 20s Exposure</td>
<td>245°C</td>
</tr>
<tr>
<td>ESD, Human Body Model (HBM)</td>
<td>–2000 to 2000V</td>
</tr>
</tbody>
</table>

[c] See Figure 11 for the current de-rating curve.

**Electrical Characteristics**

Parameter limits apply over the operating temperature range unless otherwise noted.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUS+ to BUS– Input Range</td>
<td>Measured at 7A, 85°C ambient temperature[k]</td>
<td>80</td>
<td></td>
<td></td>
<td>V&lt;sub&gt;DC&lt;/sub&gt;</td>
</tr>
<tr>
<td>BUS+ to QPI+ Voltage Drop</td>
<td>Measured at 7A, 85°C ambient temperature[k]</td>
<td>130</td>
<td></td>
<td></td>
<td>mV&lt;sub&gt;DC&lt;/sub&gt;</td>
</tr>
<tr>
<td>BUS– to QPI– Voltage Drop</td>
<td>Measured at 7A, 85°C ambient temperature[k]</td>
<td>130</td>
<td></td>
<td></td>
<td>mV&lt;sub&gt;DC&lt;/sub&gt;</td>
</tr>
<tr>
<td>Common-Mode Attenuation</td>
<td>V&lt;sub&gt;bus&lt;/sub&gt; = 48V, Frequency = 1.0MHz, line impedance = 50Ω</td>
<td>45</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Differential-Mode Attenuation</td>
<td>V&lt;sub&gt;bus&lt;/sub&gt; = 48V, Frequency = 1.0MHz, line impedance = 50Ω</td>
<td>75</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Input Bias Current at 50V</td>
<td>Input current from BUS+ to BUS–</td>
<td>10</td>
<td></td>
<td></td>
<td>µA</td>
</tr>
</tbody>
</table>

[k] See Figure 11 for the current de-rating curve.
Package Pinout

<table>
<thead>
<tr>
<th>Pad Number</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8, 9</td>
<td>BUS+</td>
<td>Positive bus potential</td>
</tr>
<tr>
<td>1, 10</td>
<td>BUS–</td>
<td>Negative bus potential</td>
</tr>
<tr>
<td>6, 7</td>
<td>QPI+</td>
<td>Positive input to the converter</td>
</tr>
<tr>
<td>4, 5</td>
<td>QPI–</td>
<td>Negative input to the converter</td>
</tr>
<tr>
<td>2, 3</td>
<td>Shield</td>
<td>Shield connects to the system chassis or to a safety ground</td>
</tr>
</tbody>
</table>
Applications Information

EMI Sources
Many of the components in today's power conversion modules are sources of high-frequency EMI noise generation. Diodes, high-frequency switching devices, transformers and inductors, and circuit layouts passing high dV/dt or dI/dt signals are all potential sources of EMI.

EMI is propagated either by radiated or conductive means. Radiated EMI can be sourced from these components as well as by circuit loops that act like antennas and broadcast the noise signals to neighboring circuit paths. This also means that these loops can act as receivers of a broadcasted signal. This radiated EMI noise can be reduced by proper circuit layout and by shielding potential sources of EMI transmission.

There are two basic forms of conducted EMI that typically need to be filtered; namely common-mode (CM) and differential-mode (DM) EMI. Differential-mode resides in the normal power loop of a power source and its load; where the signal travels from the source to the load and then returns to the source. Common-mode is a signal that travels through both leads of the source and is returned to earth via parasitic pathways, either capacitively or inductively coupled.

Figures 3 – 10 are the resulting EMI plots of the total noise, both common and differential mode, of Vicor PRM™/VTM™ and BCM® evaluation modules, under various loads, after filtering by the QPI-12LZ. The red and blue traces represent the positive and negative branches of total noise, as measured using an industry-standard LISN set up, shown in Figures 1 and 2. The PRM and VTM evaluation boards are mounted to a Vicor QPI-12-CB1 board for testing. The QPI-12-CB1 carrier is designed to accept both the PRM/VTM combination of evaluation boards, as well as the standalone BCM evaluation board.

The differential-mode EMI is typically larger in magnitude than common-mode, since common-mode is created by the physical imbalances in the differential loop path. Reducing differential EMI will cause a reduction in common-mode EMI.

EMI Filtering
The basic premise of filtering EMI is to insert a high impedance, at the EMI’s base frequency, in both the differential- and common-mode paths as it returns to the power source.

Passive filters use common-mode chokes and “Y” capacitors to filter out common-mode EMI. These chokes are designed to present a high impedance at the EMI frequency in series with the return path, and a low-impedance path to the earth signal via the “Y” caps. This network will force the EMI signals to re-circulate within a confined area and not to propagate to the outside world. Often two common-mode networks are required to filter EMI within the frequency span required to pass the EN55022 Class B limits.

The other component of the passive filter is the differential LC network. Again, the inductor is chosen such that it will present a high impedance in the differential EMI loop at the EMI's base frequency. The differential capacitor will then shunt the EMI back to its source. The QPI-12 was specifically designed to work with higher switching frequency converters like Vicor VI Chip® products; PRM, VTM and BCM modules; as well as their newer VI Brick® product series.
EMI Management

The more effectively EMI is managed at the source, namely the power converter, the less EMI attenuation the filter will have to do. The addition of “Y” capacitors to the input and output power nodes of the converter will help to limit the amount of EMI that tries to propagate to the input source.

There are two basic topologies for the connection of the recirculating “Y” capacitors. In Figure 1 the open-frame topology is shown in the Vicor EMI test setup. The “Y” capacitors (CY1 to CY4) recirculate the EMI signals between the positive input and output, and the negative input and output of the power conversion stage.

Figure 2 shows the baseplate topology of recirculating “Y” caps. Here, CY5 to CY10 are connected to each power node of the PRM™ and VTM™, and then are commomned together on a copper shield plane created under the converter. The addition of the copper shield plane helps in the containment of the radiated EMI, converting it back to conducted EMI and shunting it back to its source.

Both of these topologies work well with the PRM/VTM combination shown above in attenuating noise levels well below Class B EMI limits.

Attenuation Test Set Ups

Figure 1 — Open-frame EMI test setup using the QPI-12-CB1 carrier board with VI Chip® evaluation boards

Figure 2 — Baseplate EMI test setup using the QPI-12-CB1 carrier board with VI Chip evaluation boards
Attenuation Plots

QPI-12 with PRM™ P048F048T24AL-CB and various VTM™ modules, connected in baseplate configuration, as shown in Figure 1.

Figure 3 — VTM V048F030T070-CB with 160W load

Figure 4 — VTM V048F120T025-CB with 180W load

Figure 5 — VTM V048F240T012-CB with 172W output load

Figure 6 — VTM V048F480T006-CB with 153W load
Attenuation Plots (Cont.)

QPI-12 with various BCM® modules, connected in open-frame configuration, as shown in Figure 12.

**Figure 7** — BCM B048FO30T21-EB with 160W load

**Figure 8** — BCM B048F120T30-EB with 180W load

**Figure 9** — BCM B048F240T30-EB with 172W load

**Figure 10** — BCM B048F480T30-EB with 152W load
Current De-Rating

Mounted to QPI-12-CB1 Evaluation Board.

Figure 11 — Current de-rating over ambient temperature range
Converter Output Grounding

Recommended configurations.

**Figure 12** — BCM® converter in open-frame configuration with the output connected to chassis/earth

**Figure 13** — PRM™/VTM™ in open-frame configuration with the output connected to the chassis/earth

When using the QPI-12 with a Vicor PRM™/VTM™ or BCM® in a power system that requires the converter's output to be connected to chassis/earth, Vicor recommends using the open-frame configuration of “Y” capacitors, shown in Figure 12, to re-circulate EMI currents. A baseplate configuration could also be used with a slight decrease in EMI attenuation, but with peaks well below class B limits.

The plot in Figure 14 is of a B048F120T30, with a 125W load, with the output ground connected to the chassis. When using the open-frame configuration of “Y” caps, the EMI shield plane is not used by the “Y” capacitors for recirculating EMI currents.

This configuration would also be recommended for a QPI-12 with a PRM/VTM pair, configured as shown in the PRM/VTM typical application schematic on page 1.

The QPI-12 is not designed to be used in parallel with another QPI-12 to achieve a higher current rating, but it can be used multiple times within a system design.
QPI Insertion Loss Measurements and Test Circuits

**Figure 15** — Attenuation curves into a 50Ω line impedance, bias from a 48V bus

Insertion loss equation:

\[
\text{Insertion Loss} = 20 \log \left( \frac{I_{\text{INA}}}{I_{\text{INB}}} \right)
\]

**Figure 16** — Test set up to measure differential-mode EMI currents in Figure 15

**Figure 17** — Test set up to measure common-mode EMI currents in Figure 15

Not Recommended for New Designs
**Package Outline Drawings**

**Figure 18** — Lidded package dimensions, tolerance of ±0.004in

**Figure 19** — Open-frame package dimensions, tolerance of ±0.004in; pick-and-place from label center
Pad and Stencil Definitions

Figure 20 — Bottom view of open-frame (OF) and lidded (LID) products (all dimensions are in inches)

Figure 21 — Recommended receptor and stencil patterns (all dimensions are in inches)

Note: Stencil definition is based on a 6mil stencil thickness, 80% of LGA pad area coverage. LGA Package dimensions are for both the open-frame and lidded versions of the QPI-12.
PCB Layout Recommendations

![3D view of paralleling planes underneath the QPI-12](image)

**Figure 22 — 3D view of paralleling planes underneath the QPI-12**

**PCB Layout**

The filtering performance of the QPI-12 is sensitive to capacitive coupling between its input and output pins. Parasitic plane capacitance must be kept below one pico-Farad between inputs and outputs using the layout shown above and the recommendations described below to achieve maximum conducted EMI performance.

To avoid capacitive coupling between input and output pins, there should not be any planes or large traces that run under both input and output pins, such as a ground plane or power plane. For example, if there are two signal planes or large traces where one trace runs under the input pins, and the other under the output pins, and both planes overlap in another area, they will cause capacitive coupling between input and output pins. Also, planes that run under both input and outputs pins, but do not cross, can cause capacitive coupling if they are capacitively bypassed together. Figure 22 shows the recommended PCB layout on a two-layer board. Here, the top layer planes are duplicated on the bottom layer so that there can be no overlapping of input and output planes. This method can be used for boards of greater layer count.

**QPI-12 Mechanical Data**

<table>
<thead>
<tr>
<th>Datum</th>
<th>Units</th>
<th>QPI-12LZ</th>
<th>QPI-12LZ-01</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>FITS</td>
<td>Failure/Billion Hrs</td>
<td>16</td>
<td>16</td>
<td>FITS based on the BellCore Standard TR-332</td>
</tr>
<tr>
<td>MTBF</td>
<td>Million Hrs</td>
<td>62.5</td>
<td>62.5</td>
<td>MTBFs based on the BellCore Standard TR-332</td>
</tr>
<tr>
<td>Weight</td>
<td>grams</td>
<td>2.4</td>
<td>2.075</td>
<td></td>
</tr>
<tr>
<td>MSL</td>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Peak Reflow Temperature</td>
<td>°C/20 seconds</td>
<td>245</td>
<td>245</td>
<td>IPC/JEDEC J-STD-020D</td>
</tr>
</tbody>
</table>

**Post-Solder Cleaning**

LZ version SiPs are not hermetically sealed and must not be exposed to liquid, including but not limited to cleaning solvents, aqueous washing solutions or pressurized sprays. When soldering, it is recommended that no-clean flux solder be used, as this will ensure that potentially corrosive mobile ions will not remain on, around or under the module following the soldering process. For applications where the end product must be cleaned in a liquid solvent, Vicor recommends using the QPI-12LZ-01, open-frame version of the EMI filter.
Vicor’s comprehensive line of power solutions includes high density AC-DC and DC-DC modules and accessory components, fully configurable AC-DC and DC-DC power supplies, and complete custom power systems.

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