Purpose

This demo is for CoreVectorBlox neural network acceleration on the PolarFire® field-programmable gate array (FPGA) devices. This document provides instructions on how to use the corresponding reference design.

Intended Audience

This demo guide is intended for:

- FPGA designers
- Firmware designers
- System level designers
- Data scientists

References

The following documents are referred in this demo guide.

- CoreVectorBlox SDK Programmer's Guide
- CoreVectorBlox IP Handbook
Table of Contents

Purpose.......................................................................................................................................................... 1
Intended Audience......................................................................................................................................... 1
References..................................................................................................................................................... 1

1. Introduction............................................................................................................................................. 3

2. Design Requirements.............................................................................................................................. 4

3. Development Kit for Demo...................................................................................................................... 5

4. Demo Design Description....................................................................................................................... 6
   4.1. System Design............................................................................................................................. 6

5. Setting Up the Demo............................................................................................................................... 7
   5.1. Setting Up the Hardware.............................................................................................................. 7
   5.2. Programming the PolarFire Device.............................................................................................. 7

6. Running Alternate Models..................................................................................................................... 11
   6.1. Obtaining Model File................................................................................................................... 11
   6.2. Modifying the SPI Flash Configuration....................................................................................... 11
   6.3. SoftConsole Project.................................................................................................................... 11
   6.4. Running the Mi-V Program......................................................................................................... 12

7. Revision History.................................................................................................................................... 13

The Microchip Website................................................................................................................................. 14
Product Change Notification Service............................................................................................................ 14
Customer Support........................................................................................................................................ 14
Microchip Devices Code Protection Feature................................................................................................14
Legal Notice................................................................................................................................................. 14
Trademarks.................................................................................................................................................. 15
Quality Management System....................................................................................................................... 15
Worldwide Sales and Service....................................................................................................................... 16
1. Introduction

This document describes how to run the CoreVectorBlox Neural Network using the PolarFire Video Kit, the Dual Camera sensor module, and an HDMI monitor. The demo design features a fully integrated solution developed using Microchip Libero® SoC software to help customers evaluate PolarFire FPGA in Neural Network Vision applications and to build prototypes quickly. For more information, see Smart Embedded Vision.

The demo demonstrates the following functions:

- MIPI CSI-2 RX to read one of the cameras
- HDMI display controller
- VectorBlox CNN acceleration of Tiny YOLOv3
- VectorBlox CNN acceleration of MobileNet V1
- Image enhancements such as contrast, brightness, and color balance

The PolarFire Video Kit (MPF300-VIDEO-KIT-NS) includes the following components:

- A 300K LE FPGA (MPF300T, FCG1152)
- HDMI 1.4 transmitter (ADV7511) chipset and corresponding connector
- HDMI 2.0 with rail clamps, ReDrivers, and corresponding connectors
- Dual camera sensor featuring IMX334 Sony image sensor
- Image sensor interface to support up to two MIPI CSI-2 cameras
- Display Serial Interface (DSI)
- NVIDIA® Jetson interface (MIPI CSI-2 TX connector)
- A High Pin Count (HPC) FMC connector to connect to high-speed interfaces (such as 12G-SDI and USXGMII)

For more information about the video kit, see PolarFire FPGA Video and Imaging Kit.
## Design Requirements

The following table lists the hardware and software required to run the demo.

<table>
<thead>
<tr>
<th>Design Requirements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardware Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>PolarFire Video Kit Development Board</td>
<td>MPF300-VIDEO-KIT-NS</td>
</tr>
<tr>
<td>USB A to mini-B cable(1)</td>
<td>Required for the following:</td>
</tr>
<tr>
<td></td>
<td>• FPGA programming and SPI Flash programming</td>
</tr>
<tr>
<td></td>
<td>• Running the modified Mi-V C code from SoftConsole</td>
</tr>
<tr>
<td>HDMI cable(1)</td>
<td>HDMI A Male to Male cable</td>
</tr>
<tr>
<td>Power adapter(1)</td>
<td>12V, 5A</td>
</tr>
<tr>
<td>HDMI monitor</td>
<td>A 1920 x1080 60 Hz resolution monitor for the HDMI 1.4 TX port</td>
</tr>
<tr>
<td>Host PC</td>
<td>A host PC with a USB port</td>
</tr>
<tr>
<td><strong>Software Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>Libero® System-on-Chip (SoC) v12.5</td>
<td>You must install the full Libero SoC software and not just the programming</td>
</tr>
<tr>
<td></td>
<td>tools to program the SPI Flash, which cannot be done from FPExpress.</td>
</tr>
<tr>
<td></td>
<td>A Libero license is necessary; the video kit comes with a Gold license</td>
</tr>
<tr>
<td></td>
<td>or an evaluation license that can be obtained from the Licensing tab of the</td>
</tr>
<tr>
<td></td>
<td>following page.</td>
</tr>
<tr>
<td></td>
<td>Libero SoC v12.0 and later</td>
</tr>
</tbody>
</table>

**Note:**

1. Included with the PolarFire Video Kit.
3. Development Kit for Demo

The following figure highlights the features of PolarFire Video Kit.

Figure 3-1. PolarFire Video Kit Features

The following table provides the jumper position and functionality for the jumper settings.

Table 3-1. Jumper Description

<table>
<thead>
<tr>
<th>Jumper</th>
<th>Default Position</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>J15</td>
<td>Open</td>
<td>SPI Slave and Master mode selection. Default: SPI master.</td>
</tr>
<tr>
<td>J17</td>
<td>Open</td>
<td>100K PD for TRSTn. Default: 1K PD is connected.</td>
</tr>
<tr>
<td>J19</td>
<td>Pin 1 and 2</td>
<td>Default: XCVR_VREF is connected to GND.</td>
</tr>
<tr>
<td>J28</td>
<td>Pin 1 and 2</td>
<td>Default: Programming through the FTDI.</td>
</tr>
<tr>
<td>J24</td>
<td>Pin 2 and 4</td>
<td>Default: VDDAUX4 voltage is set to 3V3.</td>
</tr>
<tr>
<td>J25</td>
<td>Pin 5 and 6</td>
<td>Default: Bank4 voltage is set to 1V8.</td>
</tr>
<tr>
<td>J36</td>
<td>Pin 1 and 2</td>
<td>Default: Board power up through SW4.</td>
</tr>
</tbody>
</table>
4. **Demo Design Description**
The following section provides an overview of the dataflow in the demo design.

4.1 **System Design**
The following diagram illustrates an overview of the dataflow in the design.

**Figure 4-1. System Dataflow**

Sequence of dataflow shown in the figure above is as follows:

1. Video frame is received through MIPI CSI-2.
2. It is stored in DDR through AXI-4 interconnect.
3. Before inference—the frame is read back from DDR.
4. Converted from RAW to RGB, RGB to planer R, G, B and written back into DDR.
5. CoreVectorBlox engine runs inference on R, G, B arrays and writes results back into DDR.
6. Mi-V sorts probabilities, creates an overlay frame with bounding boxes, classification results, fps etc. and stores the frame in DDR.
7. The original video frame, as read in step 3, is blended with the overlay frame and sent out to an HDMI display.
5. Setting Up the Demo
The following steps describe how to setup the demo.
1. Setting up the Hardware
2. Programming the PolarFire Device
3. Programming the SPI Flash

5.1 Setting Up the Hardware
Setting up the hardware involves interfacing the dual camera sensor module and the HDMI monitor with the PolarFire Video Kit, and verifying the jumper settings.

Perform the following steps.
1. Connect the J1 connector of the dual camera sensor module to the J5 interface of the video kit. The video kit is already shipped with this.
2. Connect the Full HD HDMI monitor to J2 (HDMI 1.4 TX port) of the video kit using the HDMI cable.
3. Connect the host PC and the video kit to J12 of the video kit using the USB mini cable.
4. Connect the power supply cable to J20 of the video kit.
5. Ensure that the jumper settings are set on the video kit. The video kit is shipped in this configuration. For jumper position and functionality, see Table 3-1.
6. Power-up the HDMI monitor.
7. Power-up the board using the SW4 slide switch.

The PolarFire dual camera video and imaging hardware set up is completed.

5.2 Programming the PolarFire Device
The following section describes how to program the PolarFire device and run the demo.

5.2.1 Extracting the Source files and Opening the Project
Before unzipping the archive containing the libero project, first "unblock" the file. This is necessary to ensure that Windows does not change the timestamps of the files during extraction. To unblock the file, right click the zip file, select Properties and check Unblock, then click OK.

After unzipping the archive, launch Libero SoC v12.5, and open the .prjx project file.

Note: You may be prompted to update Libero SoC or individual IP cores, ignore these prompts.
5.2.2 Programming the Device

Perform the following steps.

1. In the Design Flow window, double click Run PROGRAM Action.

Figure 5-1. Run PROGRAM ACTION
2. To program the SPI Flash, double click **Configure Design Initialization Data and Memories**.

**Note:** The model and firmware files are configured to be programmed into the SPI Flash chip. There are other files listed (ascii_characters.hex and logo.hex) that are used for drawing the results of the models onto the HDMI connected screen.

**Figure 5-2. Configure Design Initialization Data and Memories**

Refer to the following table for contents in the SPI Flash Hex file.

**Table 5-1. SPI Flash Contents**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firmware</td>
<td>CoreVectorBlox firmware BLOB</td>
</tr>
<tr>
<td>characters</td>
<td>Character set for overlay display</td>
</tr>
<tr>
<td>mobilenetV1</td>
<td>MobileNetV1 model BLOB</td>
</tr>
<tr>
<td>yolov3</td>
<td>Tiny YOLOv3 model BLOB</td>
</tr>
<tr>
<td>logo</td>
<td>Microchip logo for overlay display</td>
</tr>
<tr>
<td>INIT_STAGE_3_SPI_CLIENT</td>
<td>Mi-V demo code</td>
</tr>
</tbody>
</table>
3. Double click **Run PROGRAM_SPI_IMAGE Action** and wait. This will take some time.  
   **Note:** In Windows, you might be prompted with a firewall popup.

**Figure 5-3. Run PROGRAM_SPI_IMAGE Action**

5.2.3 **Running the Demo**

Power cycle the board with SW4 to start the demo.

The startup might take a few minutes. The following events occur during the startup: the camera is calibrated to the brightness of the environment, the firmware and models are read from the flash into DDR, and the models are tested with the test data.

After the startup is completed, the demo will switch every 5 seconds between MobileNet V1 and YOLOv3.
6. Running Alternate Models

The project that is provided here runs only two models: MobileNet V1 and Tiny YOLOv3. However, it is capable of running many other networks. In this document, you will see an example of swapping out Tiny YOLOv3 for Tiny YOLOv2.

The following sections describe how to run the alternate models.

6.1 Obtaining Model File

The model files can be obtained by running the tutorial available in the VectorBlox SDK (available separately). Instructions for running the tutorials can be found in the Programmer's Guide available as part of the SDK documentation. The artifact generated from the tutorial that needs to be stored is yolov2-tiny-voc.hex. This hex file will be added to the SPI Flash on the board.

6.2 Modifying the SPI Flash Configuration

Perform the following steps in Libero.

1. To change the file pointed to by the YOLO data client to the generated file, highlight the TinyYoloV3.hex, click the Edit button, and change the path to point to yolov2-tiny-voc.hex (file described in the preceding section, Obtaining Model File).
   **Note:** Ensure the address range does not overlap with other clients in the Flash memory.

2. Click Apply.

3. In the Design Flow window, double click Run PROGRAM_SPI_FLASH Action (see Step 3 in the Programming the Device section).

4. After the SPI programming is complete, power cycle the board using SW4.

6.3 SoftConsole Project

Before the new model is run on the FPGA, the software running on Mi-V must be modified as described in this section.

A SoftConsole project is located in the Libero Design zip archive at Download_Directory/videokit.v1000/softconsole. Open that directory as a workspace with SoftConsole 6.2.

In the VideoKit project locate and open main.c. The following code can be seen in or on line 289.

```c
struct model_descr_t models[] = {
    "MobileNet V1",0x259000,224,IMAGENET,10,0xf203f880,30,
    "Tiny Yolo V3 COCO",0xed5000,416,YOLOV3,30,0x8d989534,30,
};
```

Change the code to the following.

```c
struct model_descr_t models[] = {
    "MobileNet V1",0x259000,224,IMAGENET,10,0xf203f880,30,
    "Tiny Yolo V2 VOC",0xed5000,416,YOLOV2,30,0,0,
};
```

Where, parameters in the structure are as follows:

- Display name of the model
- Address in the SPI Memory in which the model is stored.
- Resolution of the square input image needed for the network.
  **Note:** Resolution of the network should be documented by the network provider. For instance, OpenVino's open-model-zoo; it can link to https://github.com/openvinotoolkit/open_model_zoo.
- The type of postprocessing for displaying the network. Currently, IMAGENET (Resnet/Mobilenet/etc.), YOLOv2, and YOLOv3 are implemented.
• The maximum number of frames per second to run at. Used to reduce the rate of change of displayed labels to make the network output readable.
• The last two parameters are for verification at boot time.
  – The first is the correct checksum of the network running the built in test input.
  – The second is the number of self test runs to perform. If the correct checksum is unknown for a network, set them both to 0 to disable the boot time verification.

After these modifications are performed, the software will run and models can be executed.

### 6.4 Running the Mi-V Program

To run the Mi-V program, click the button in the toolbar.
7. Revision History
The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>11/2020</td>
<td>Updated to 1.0 Release</td>
</tr>
<tr>
<td>A</td>
<td>08/2020</td>
<td>Initial Revision</td>
</tr>
</tbody>
</table>
The Microchip Website

Microchip provides online support via our website at www.microchip.com/. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user’s guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip design partner program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Product Change Notification Service

Microchip’s product change notification service helps keep customers current on Microchip products. Subscribers will receive email notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, go to www.microchip.com/pcn and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Embedded Solutions Engineer (ESE)
- Technical Support

Customers should contact their distributor, representative or ESE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in this document.

Technical support is available through the website at: www.microchip.com/support

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip’s Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip’s code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Legal Notice

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with
your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER
EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION,
INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR
FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip
devices in life support and/or safety applications is entirely at the buyer’s risk, and the buyer agrees to defend,
indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such
use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless
otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AnyRate, AVR, AVR logo, AVR Freaks, BestTime,
BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, HELDO, IGLOO, JukeBlox,
KeeLoq, Kleer, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST,
MOST logo, MPLAB, OptoLyzer, PackeTime, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer,
QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon,
TempTracker, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology
Incorporated in the U.S.A. and other countries.

APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, FlashTec, Hyper Speed Control,
HyperLight Load, IntelliMOS, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus,
ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider,
Vite, WinPath, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, Anylin, AnyOut, BlueSky, BodyCom,
CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM,
dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP,
INICnet, Inter-Chip Connectivity, JitterBlocker, KleerNet, KleerNet logo, memBrain, Mindi, MiWi, MPASM, MPF,
MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM,
PICDEM.net, PICkit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, SAM-ICE, Serial Quad
I/O, SMART-I.S., SQI, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense,
ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A.
and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of
Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II Gmb & Co. KG, a subsidiary of Microchip
Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2020, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.


Quality Management System

For information regarding Microchip’s Quality Management Systems, please visit www.microchip.com/quality.
<table>
<thead>
<tr>
<th>AMERICAS</th>
<th>ASIA/PACIFIC</th>
<th>ASIA/PACIFIC</th>
<th>EUROPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate Office</td>
<td>Australia - Sydney</td>
<td>India - Bangalore</td>
<td>Austria - Wels</td>
</tr>
<tr>
<td>2355 West Chandler Blv.</td>
<td>Tel: 61-2-9868-6733</td>
<td>Tel: 91-80-3090-4444</td>
<td>Tel: 43-7242-2244-39</td>
</tr>
<tr>
<td>Chandler, AZ 85224-6199</td>
<td>China - Beijing</td>
<td>India - New Delhi</td>
<td>Fax: 43-7242-2244-393</td>
</tr>
<tr>
<td>Tel: 480-792-7200</td>
<td>China - Chengdu</td>
<td>India - Pune</td>
<td>Denmark - Copenhagen</td>
</tr>
<tr>
<td>Fax: 480-792-7277</td>
<td>China - Chongqing</td>
<td>Japan - Osaka</td>
<td>Tel: 45-4485-5910</td>
</tr>
<tr>
<td>Technical Support</td>
<td>China - Dongguan</td>
<td>Japan - Tokyo</td>
<td>Fax: 45-4485-2829</td>
</tr>
<tr>
<td><a href="http://www.microchip.com/support">www.microchip.com/support</a></td>
<td>Tel: 86-769-8702-9880</td>
<td>Tel: 81-3-6880-3770</td>
<td>Finland - Espoo</td>
</tr>
<tr>
<td>Web Address:</td>
<td>China - Guanzhou</td>
<td>Korea - Daegu</td>
<td>Tel: 358-9-4520-820</td>
</tr>
<tr>
<td><a href="http://www.microchip.com">www.microchip.com</a></td>
<td>Tel: 86-20-8755-8029</td>
<td>Korea - Seoul</td>
<td>France - Paris</td>
</tr>
<tr>
<td>Atlanta</td>
<td>China - Hangzhou</td>
<td>Tel: 82-53-744-4301</td>
<td>Tel: 33-1-69-53-63-20</td>
</tr>
<tr>
<td>Duluth, GA</td>
<td>China - Hong Kong SAR</td>
<td>China - Kuala Lumpur</td>
<td>Fax: 33-1-69-30-90-79</td>
</tr>
<tr>
<td>Tel: 678-957-9614</td>
<td>Tel: 852-2943-5100</td>
<td>Malaysia - Penang</td>
<td>Germany - Garching</td>
</tr>
<tr>
<td>Fax: 678-957-1455</td>
<td>China - Nanjing</td>
<td>Tel: 82-2-554-7200</td>
<td>Tel: 49-8931-9700</td>
</tr>
<tr>
<td>Austin, TX</td>
<td>Tel: 86-25-8473-2460</td>
<td>Philippines - Manila</td>
<td>Germany - Haan</td>
</tr>
<tr>
<td>Tel: 512-257-3370</td>
<td>China - Qingdao</td>
<td>Tel: 63-2-634-9065</td>
<td>Tel: 49-2129-3766400</td>
</tr>
<tr>
<td>Boston</td>
<td>China - Shanghai</td>
<td>Singapore</td>
<td>Germany - Heilbronn</td>
</tr>
<tr>
<td>Westborough, MA</td>
<td>Tel: 86-21-3326-8000</td>
<td>Tel: 65-6334-8870</td>
<td>Tel: 49-7131-72400</td>
</tr>
<tr>
<td>Tel: 774-760-0087</td>
<td>China - Shenyang</td>
<td>Taiwan - Hsin Chu</td>
<td>Germany - Karlsruhe</td>
</tr>
<tr>
<td>Fax: 774-760-0088</td>
<td>Tel: 86-24-2334-2829</td>
<td>Tel: 886-3-577-8366</td>
<td>Tel: 49-721-625370</td>
</tr>
<tr>
<td>Chicago</td>
<td>China - Shenzhen</td>
<td>Taiwan - Kaohsiung</td>
<td>Germany - Munich</td>
</tr>
<tr>
<td>Itasca, IL</td>
<td>Tel: 86-755-8864-2200</td>
<td>Tel: 886-7-213-7830</td>
<td>Tel: 49-89-627-144-0</td>
</tr>
<tr>
<td>Tel: 630-285-0071</td>
<td>China - Suzhou</td>
<td>Taiwan - Taipei</td>
<td>Fax: 49-89-627-144-44</td>
</tr>
<tr>
<td>Fax: 630-285-0075</td>
<td>Tel: 86-186-6233-1526</td>
<td>Tel: 886-2-2508-8600</td>
<td>Germany - Rosenheim</td>
</tr>
<tr>
<td>Dallas</td>
<td>China - Wuhan</td>
<td>Thailand - Bangkok</td>
<td>Tel: 49-8031-354-560</td>
</tr>
<tr>
<td>Addison, TX</td>
<td>Tel: 86-27-5980-5300</td>
<td>Tel: 66-2-694-1351</td>
<td>Israel - Ra’anana</td>
</tr>
<tr>
<td>Tel: 972-818-7423</td>
<td>China - Xian</td>
<td>Vietnam - Ho Chi Minh</td>
<td>Tel: 972-9-744-7705</td>
</tr>
<tr>
<td>Fax: 972-818-2924</td>
<td>Tel: 86-29-8833-7252</td>
<td>Tel: 84-28-5448-2100</td>
<td>Italy - Milan</td>
</tr>
<tr>
<td>Detroit</td>
<td>China - Xiamen</td>
<td></td>
<td>Tel: 39-0331-742611</td>
</tr>
<tr>
<td>Novi, MI</td>
<td>Tel: 86-992-2388138</td>
<td></td>
<td>Fax: 39-0331-466781</td>
</tr>
<tr>
<td>Tel: 248-848-4000</td>
<td>China - Zhuhai</td>
<td></td>
<td>Italy - Padova</td>
</tr>
<tr>
<td>Houston, TX</td>
<td>Tel: 86-756-3210040</td>
<td></td>
<td>Tel: 39-049-7625286</td>
</tr>
<tr>
<td>Tel: 281-894-5983</td>
<td></td>
<td></td>
<td>Netherlands - Drunen</td>
</tr>
<tr>
<td>Indianapolis</td>
<td></td>
<td></td>
<td>Tel: 31-416-690399</td>
</tr>
<tr>
<td>Noblesville, IN</td>
<td></td>
<td></td>
<td>Fax: 31-416-690340</td>
</tr>
<tr>
<td>Tel: 317-773-8323</td>
<td></td>
<td></td>
<td>Norway - Trondheim</td>
</tr>
<tr>
<td>Fax: 317-773-5453</td>
<td></td>
<td></td>
<td>Tel: 47-72864388</td>
</tr>
<tr>
<td>Tel: 317-536-2380</td>
<td></td>
<td></td>
<td>Poland - Warsaw</td>
</tr>
<tr>
<td>Los Angeles</td>
<td></td>
<td></td>
<td>Tel: 48-22-3325737</td>
</tr>
<tr>
<td>Mission Viejo, CA</td>
<td></td>
<td></td>
<td>Romania - Bucharest</td>
</tr>
<tr>
<td>Tel: 949-462-9523</td>
<td></td>
<td></td>
<td>Tel: 40-21-407-87-50</td>
</tr>
<tr>
<td>Fax: 949-462-9608</td>
<td></td>
<td></td>
<td>Spain - Madrid</td>
</tr>
<tr>
<td>Tel: 951-273-7800</td>
<td></td>
<td></td>
<td>Tel: 34-91-708-08-90</td>
</tr>
<tr>
<td>Raleigh, NC</td>
<td></td>
<td></td>
<td>Fax: 34-91-708-08-91</td>
</tr>
<tr>
<td>Tel: 919-844-7510</td>
<td></td>
<td></td>
<td>Sweden - Gothenberg</td>
</tr>
<tr>
<td>New York, NY</td>
<td></td>
<td></td>
<td>Tel: 46-31-704-60-40</td>
</tr>
<tr>
<td>Tel: 631-435-6000</td>
<td></td>
<td></td>
<td>Sweden - Stockholm</td>
</tr>
<tr>
<td>San Jose, CA</td>
<td></td>
<td></td>
<td>Tel: 46-8-5090-4654</td>
</tr>
<tr>
<td>Tel: 408-735-9110</td>
<td></td>
<td></td>
<td>UK - Wokingham</td>
</tr>
<tr>
<td>Tel: 408-436-4270</td>
<td></td>
<td></td>
<td>Tel: 44-118-921-5800</td>
</tr>
<tr>
<td>Canada - Toronto</td>
<td></td>
<td></td>
<td>Fax: 44-118-921-5820</td>
</tr>
</tbody>
</table>