

## Introduction

The Xilinx® LogiCORE™ IP Media Independent Interface (MII) to Reduced Media Independent (RMII) design provides the RMII between RMII-compliant ethernet physical media devices (PHY) and Xilinx 10/100 Mb/s ethernet cores such as the XPS LL TEMAC and XPS Ethernet Lite. These cores provide the traditional MII that requires 16 signals to communicate with an ethernet PHY. The MII to RMII core accepts the 16 signal MII interface and provides a six or seven signal interface to an RMII compliant PHY. Additionally, a fixed 50 MHz reference clock synchronizes the MII to RMII core with both interfaces. The 50 MHz reference clock can be provided by a source external to the host FPGA, or generated within the host FPGA. The MII to RMII core follows the specification defined by the RMII Consortium (version 1.0).

## Features

The MII to RMII core is a soft IP core designed for Xilinx® FPGAs and contains these features:

- Core design is based on RMII specification 1.0
- Parameter to allow automatic detection of receive throughput (transmit side always fixed throughput)
- Parameter to select fixed throughput of 10 or 100 Mbits per second
- Fixed clock frequency of 50 MHz

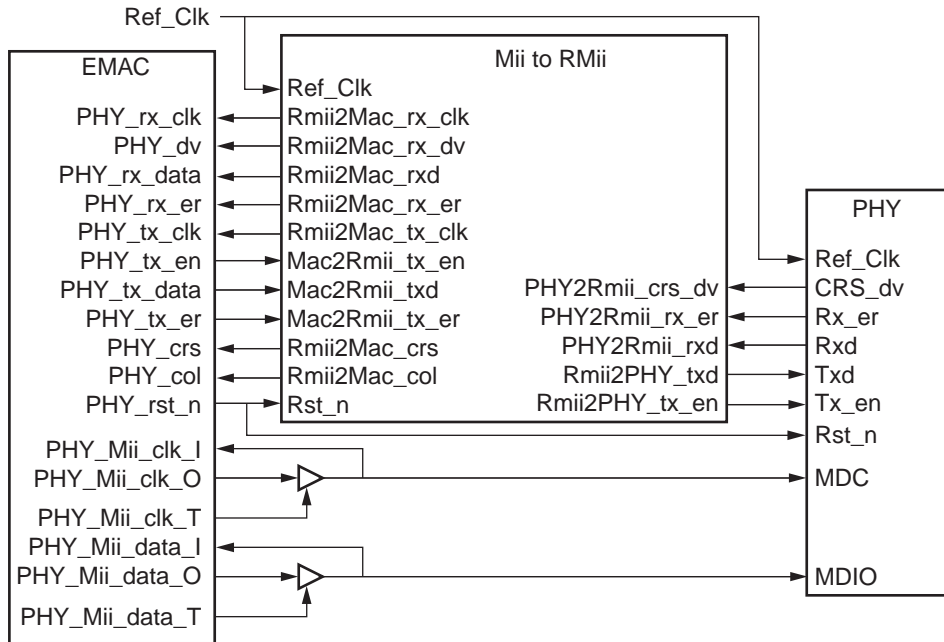
LogiCORE IP Facts Table	
<b>Core Specifics</b>	
Supported Device Family <sup>(1)</sup>	Zynq™-7000 <sup>(2)</sup> , Virtex®-7, Kintex™-7, Artix™-7, Virtex-6, Spartan®-6, Virtex-5, Virtex-4, Spartan-3, Spartan-3A, Spartan-3E
Supported User Interfaces	N/A
Resources	See <a href="#">Table 3</a> through <a href="#">Table 7</a>
<b>Provided with Core</b>	
Design Files	ISE®: VHDL Vivado™: RTL
Example Design	Not Provided
Test Bench	VHDL Test Bench
Constraints File	None
Simulation Model	None
Supported S/W Driver	N/A
<b>Tested Design Flows<sup>(3)</sup></b>	
Design Entry	Platform Studio (XPS) Vivado Design Suite <sup>(4)</sup>
Simulation	Mentor Graphic ModelSim
Synthesis	Xilinx Synthesis Technology (XST) Vivado Synthesis
<b>Support</b>	
Provided by Xilinx @ <a href="http://www.xilinx.com/support">www.xilinx.com/support</a>	

### Notes:

1. For a complete list of supported derivative devices, see the [Embedded Edition Derivative Device Support](#).
2. Supported in ISE Design Suite implementations only.
3. For the supported versions of the tools, see the [Xilinx Design Tools: Release Notes Guide](#).
4. Supports only 7 series devices.

## Functional Description

The block diagram for the MII to RMII core is shown in Figure 1. This diagram shows the usage, location, and connections for the MII to RMII core. The Ref\_Clk must be provided to clock the MII to RMII core internal to the host FPGA and external to clock the PHY. The clock can be generated either external to, or within the host FPGA, as long as provisions are made to clock all of the necessary blocks.



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Figure 1: MII to RMII Core Usage Block Diagram

## I/O Signals

The I/O signals for the MII to RMII core are listed in Table 1. The interfaces referenced in this table are shown in Figure 2 in the MII to RMII core usage diagram.

Table 1: I/O Signals

Ports	Signal Name	Interface	I/O	Description
<b>RMII PHY Interface Signals</b>				
P1	Phy2Rmii_crs_dv	PHY	I	Carrier Sense / Data Valid
P2	Phy2Rmii_rx_er	PHY	I	Receive Error (optional)
P3	Phy2Rmii_rxd	PHY	I	Receive Data, 2 bits
P4	Rmii2Phy_txd	PHY	O	Transmit Data, 2 bits
P5	Rmii2Phy_tx_en	PHY	O	Transmit Enable
<b>Ethernet MAC Interface Signals</b>				
P6	Mac2Rmii_tx_en	MAC	I	Transmit Enable
P7	Mac2Rmii_txd	MAC	I	Transmit Data, 4 bits
P8	Mac2Rmii_tx_er	MAC	I	Transmit Error
P9	Rmii2Mac_tx_clk	MAC	O	Transmit Clock

Table 1: I/O Signals (Cont'd)

Ports	Signal Name	Interface	I/O	Description
P10	Rmii2Mac_rx_clk	MAC	O	Receive Clock
P11	Rmii2Mac_col	MAC	O	Ethernet Collision
P12	Rmii2Mac_crs	MAC	O	Ethernet Carrier Sense
P13	Rmii2Mac_rx_dv	MAC	O	Receive Data Valid
P14	Rmii2Mac_rx_er	MAC	O	Receive Error
P15	Rmii2Mac_rxd	MAC	O	Receive Data, 4 bits
<b>System or MAC Interface Signals</b>				
P16	Rst_n	System or MAC	I	MII to RMII core reset (OPB Ethernet and PLB_Ethernet provide PHY_Rst_n that can be used while OPB Ethernet Lite does not provide a PHY reset.)
<b>System Interface Signals</b>				
P17	Ref_Clk	System	I	MII to RMII core and interface clock, 50 MHz

## Ports and Interfaces

Figure 2 shows the ports and interfaces for the MII to RMII core.

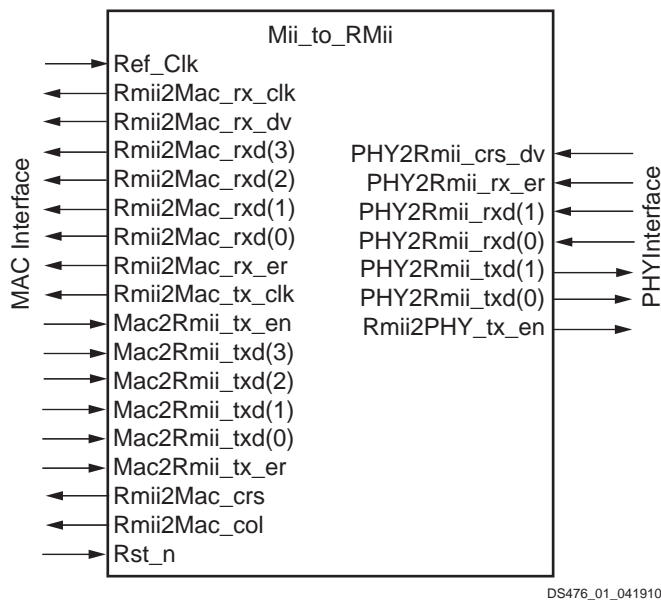


Figure 2: MII to RMII Core Ports and Interfaces

## Parameters

To allow the user to obtain an MII to RMII design that is uniquely tailored for their system, certain features are parameterizable, thereby allowing the user to have a design that only utilizes the resources required by their system and runs at the best possible performance. The features that are parameterizable in the Xilinx MII to RMII core are shown in [Table 2](#).

Table 2: Core Parameters

Generic	Feature / Description	Parameter Name	Allowable Values	Default Value	VHDL Type
<b>MII to RMII Core Parameters</b>					
G1	Fixed ethernet throughput	C_FIXED_SPEED (1)	0 = Auto (rec. only) 1 = Fixed	1	std_logic
G2	Throughput set at 100 Mb/s	C_SPEED_100	0 = 10 Mb/s 1 = 100 Mb/s	1	std_logic
<b>Notes:</b>					
1. When C_FIXED_SPEED = 0, only the receive side automatically detects ethernet throughput. The transmit side operates at a fixed throughput that is determined by C_SPEED_100. When C_FIXED_SPEED is set to 1, C_SPEED_100 determines the fixed throughput for both transmit and receive					

## Allowable Parameter Combinations

There are no restrictions on parameter combinations in the Xilinx MII to RMII core other than setting the parameters to proper logic values, 0 or 1. The note in [Table 2](#) defines the interaction of the two parameters.

## Signal Protocols

The diagrams in this section illustrate various signal protocols for the MII to RMII core. The protocols vary from transmit to receive, RMII to PHY, PHY to RMII, MII to RMII, RMII to MII, and data rates of 10 or 100 Mb/s (megabits per second). [Figure 3](#) shows a typical transaction between the physical interface, PHY, and RMII interface on the receive side operating at 100 Mb/s. Several idle dibits, 2 bits at time, can follow the assertion of `Phy2Rmii_crs_dv` and precede the preamble dibits. In this case, the `Phy2Rmii_crs_dv` remains asserted until the final packet dibit.

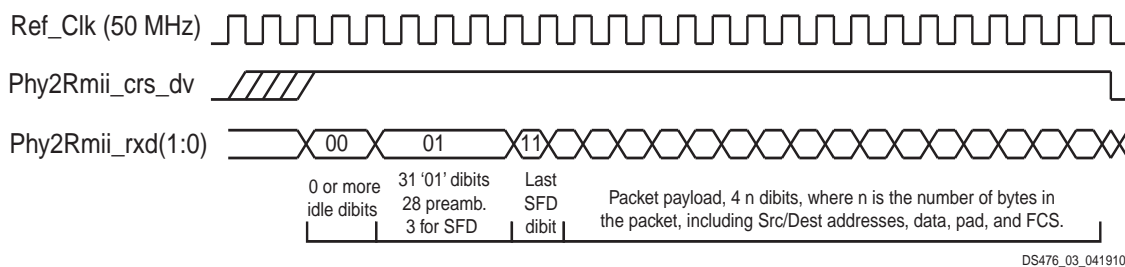


Figure 3: Typical PHY to RMII Receive Transaction at 100 Mbps

Figure 4 shows another 100 Mb/s PHY to RMI receive transaction. However, in this case `Phy2Rmii_crs_dv` deasserts on the boundary of the last nibble, where two dibits make a nibble and two nibbles make a byte. This indicates the PHY has lost the carrier but still has accumulated packet nibbles to transfer. When this occurs, the PHY cycles `Phy2Rmii_crs_dv` at 25 MHz until the final packet dibit. `Phy2Rmii_crs_dv` deasserts only on nibble boundaries.

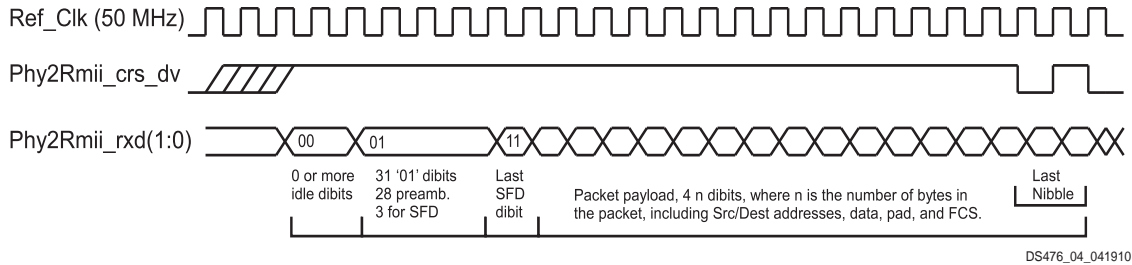


Figure 4: PHY to RMI Receive Transaction at 100 Mbps, CRS\_DV Toggles

Figure 5 shows a typical 10 Mb/s PHY to RMI receive transaction. Each dibit is asserted by the PHY for 10 Ref\_Clk clock periods.

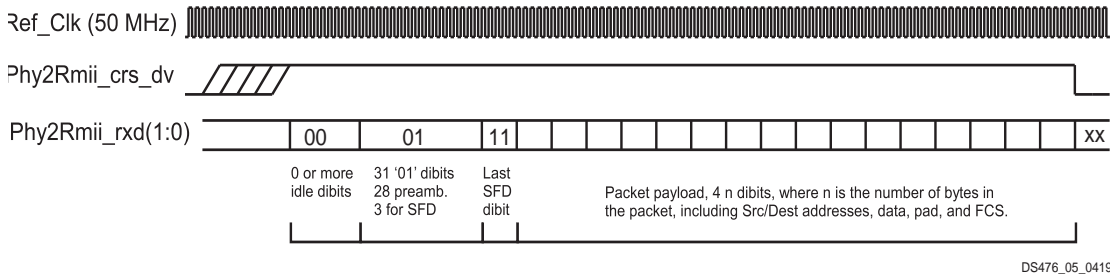


Figure 5: PHY to RMI Receive Transaction at 10 Mbps

Figure 6 shows a 10 Mb/s PHY to RMI receive transaction. In this case `Phy2Rmii_crs_dv` deasserts on the boundary of the last nibble. For 10 Mb/s transfers, the PHY cycles `Phy2Rmii_crs_dv` at 2.5 MHz until the final packet dibit. Again, the signal `Phy2Rmii_crs_dv` deasserts only on nibble boundaries.

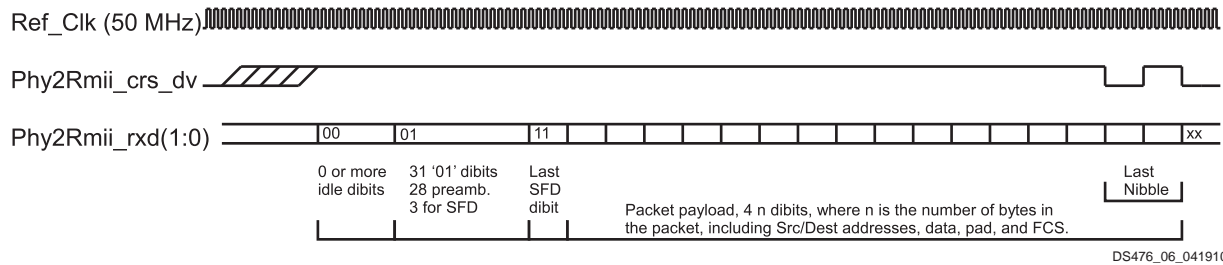


Figure 6: PHY to RMI Receive Transaction at 10 Mbps, CRS\_DV Toggles

Figure 7 shows a partial RMII to MII 100 Mb/s receive transaction. The Rmii2Mac\_rx\_clk toggles at 25 MHz with Rmii2Mac\_rx\_dv and Rmii2Mac\_rxd transitioning on the falling edge of Rmii2Mac\_rx\_clk to provide ample setup and hold times. When Rmii2Mac\_rx\_dv is deasserted, Rmii2Mac\_rxd presents 0x0000, idle, to the MAC.

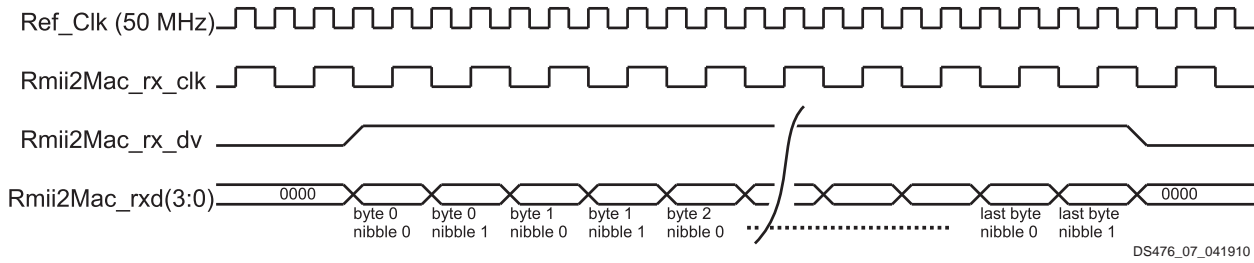


Figure 7: RMII to MII Receive Transaction at 100 Mbp

Figure 8 shows a partial 10 Mb/s RMII to MII receive transaction. The Rmii2Mac\_rx\_clk toggles at 2.5 MHz with Rmii2Mac\_rx\_dv and Rmii2Mac\_rxd transitioning on the falling edge of Rmii2Mac\_rx\_clk to provide ample setup and hold times. When Rmii2Mac\_rx\_dv is deasserted, Rmii2Mac\_rxd presents 0x0000, idle, to the MAC. The timing is 20 periods of Ref\_Clk for each Rmii2Mac\_rx\_clk period.

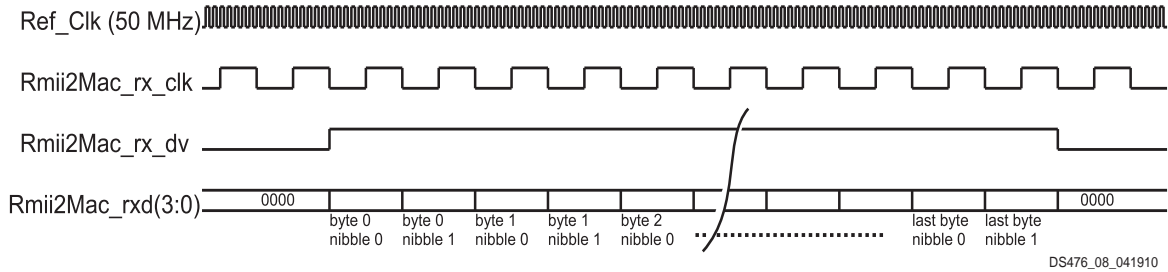


Figure 8: RMII to MII Receive Transaction at 10 Mbps

Figure 9 shows a partial 100 Mb/s MII to RMII transmit transaction. The Rmii2Mac\_tx\_clk toggles at 25 MHz with Mac2Rmii\_tx\_en and Mac2Rmii\_txd transitioning just after the rising edge of Rmii2Mac\_tx\_clk.

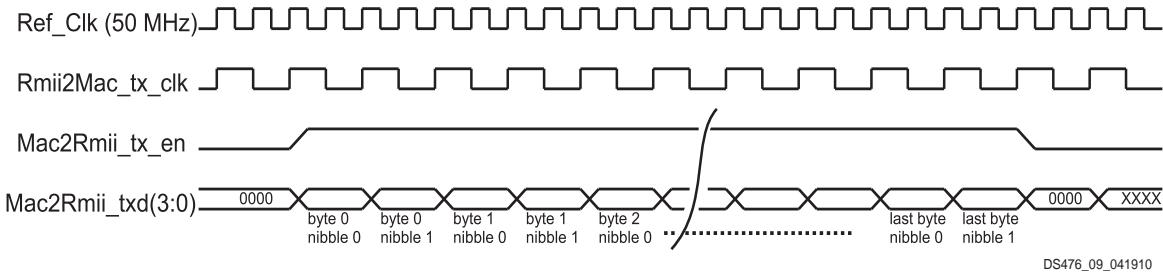


Figure 9: MII to RMII Transmit Transaction at 100 Mbps

Figure 10 shows a partial 10 Mb/s MII to RMII transmit transaction. The `Rmii2Mac_tx_clk` toggles at 2.5 MHz with `Mac2Rmii_tx_en` and `Mac2Rmii_txd` transitioning just after the rising edge of `Rmii2Mac_tx_clk`.

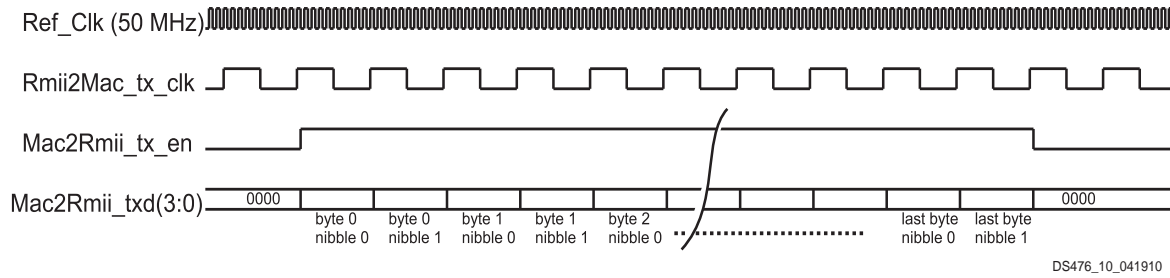


Figure 10: MII to RMII Transmit Transaction at 10 Mbps

Figure 11 shows a partial 100 Mb/s RMII to PHY transmit transaction. The `Rmii2Mac_tx_clk` toggles at 25 MHz with `Mac2Rmii_tx_en` and `Mac2Rmii_txd` transitioning just after the rising edge of `Rmii2Mac_tx_clk`.

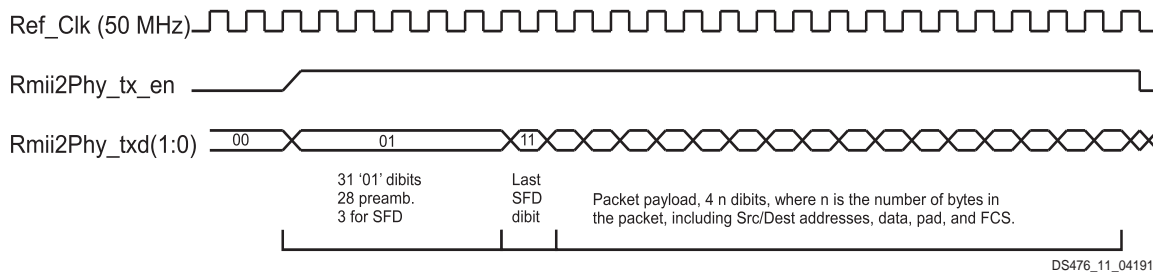


Figure 11: RMII to PHY Transmit Transaction at 100 Mbps

Figure 12 shows a partial 10 Mb/s RMII to PHY transmit transaction. The `Rmii2Mac_tx_clk` toggles at 2.5 MHz with `Mac2Rmii_tx_en` and `Mac2Rmii_txd` transitioning just after the rising edge of `Rmii2Mac_tx_clk`.

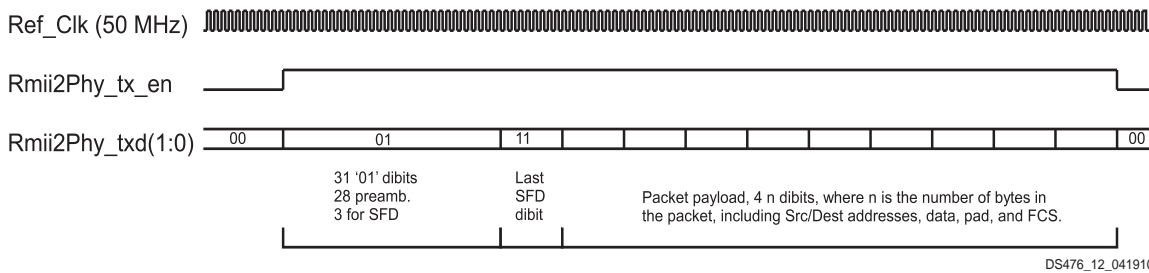


Figure 12: RMII to PHY Transmit Transaction at 10 Mbps

## Design Implementation

### Design Tools

The Xilinx Synthesis Tool is used to synthesize the MII to RMII core.

### Design Verification

The MII to RMII core has been verified through extensive simulation. VHDL test benches were created to simulate functionality and compare operation to the requirements defined by the RMII Consortium Specification.

## Target Technology

The intended target technology is listed in the Supported Device Family field of the [LogiCORE IP Facts Table](#).

## Design Constraints

The MII to RMI core requires design constraints to guarantee performance. These constraints should be placed in a UCF for the top level of the design. The example of the constraint text shown in [Figure 13](#) is based on the port names of the MII to RMI core. If these ports are mapped to FPGA pin names that are different, the FPGA pin names should be substituted for the port names in the following example. The constraints listed assume that the core is directly interfaced with the external Ethernet core and that the pins listed in [Figure 13](#) actually appear on the FPGA IOBs.

```
NET 'Ref_Clk' TNM_NET = 'Ref_Clk_GRP';
TIMESPEC 'TSTXOUT' = FROM 'Ref_Clk_GRP' TO 'PADS' 5 ns;
TIMESPEC 'TSRXIN' = FROM 'PADS' TO 'Ref_Clk_GRP' 3 ns;
NET 'Ref_Clk' USELOWSKEWLINES;
NET 'Rmii2Mac_tx_clk' USELOWSKEWLINES;
NET 'Rmii2Mac_rx_clk' USELOWSKEWLINES;
NET 'Ref_Clk' MAXSKEW= 2.0 ns;
NET 'Rmii2Mac_tx_clk' MAXSKEW= 2.0 ns;
NET 'Rmii2Mac_rx_clk' MAXSKEW= 2.0 ns;

NET 'Ref_Clk' PERIOD = 20 ns HIGH 6 ns;
NET 'Rmii2Mac_tx_clk' PERIOD = 40 ns HIGH 18 ns; # 100 Mb/s
NET 'Rmii2Mac_rx_clk' PERIOD = 40 ns HIGH 18 ns; # 100 Mb/s

NET 'Phy2Rmii_rxd<1>' NODELAY;
NET 'Phy2Rmii_rxd<0>' NODELAY;
NET 'Phy2Rmii_crs_dv' NODELAY;
NET 'Phy2Rmii_rx_er' NODELAY;

INST Phy2Rmii_rxd<1> IOB = true;
INST Phy2Rmii_rxd<0> IOB = true;
INST Phy2Rmii_crs_dv IOB = true;
INST Phy2Rmii_rx_er IOB = true;
INST Rmii2Phy_txd IOB = true;
INST Rmii2Phy_tx_en IOB = true;
```

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*Figure 13: Timing Constraints When the Core Has Direct External Interface*



The following example of the constraint text is based on the port names of the MII to RMI core. If the core has an interface with the XPS Ethernet Lite core in the targeted FPGA, the constraints listed in Figure 14 should be used.

```
NET "Ref_Clk" USELOWSKEWLINES;
NET "Rmii2Mac_tx_clk" USELOWSKEWLINES;
NET "Rmii2Mac_rx_clk" USELOWSKEWLINES;

INST Rmii2Phy_txd IOB = True;
INST RmiiPhy_tx_en IOB = True;
```

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Figure 14: Timing Constraints When the Core Has Internal-to-FPGA Interface with Cores Such as XPS Ethernet Lite

See "UCF to XDC Constraints Conversion" section in UG814, *Vivado Design Suite Getting Started Guide* for converting UCF constraints to XDC constraints.

### Device Utilization and Performance Benchmarks

Table 3 shows the MII to RMI core performance and device utilization benchmarks for the Kintex-7 FPGA and Zynq-7000 device.

Table 3: Performance and Resource Utilization Benchmarks for Kintex-7 FPGA<sup>(2)</sup> and Zynq-7000 Device

Parameter Values		Device Resources		Performance
C_FIXED_SPEED	C_SPEED_100	Slice Flip-Flops	LUTs	F <sub>Max</sub> (MHz)
0	0	140	101	224
0	1	137	97	215
1	0	72	46	209
1	1	56	38	274

**Notes:**

1. These benchmark designs contain only the MII to RMI device with registered inputs/outputs without any additional logic. Benchmark numbers approach the performance ceiling rather than representing performance under typical user conditions.
2. Kintex-7 (XC7K410TFFG900-1)

Table 4 shows the MII to RMI core performance and device utilization benchmarks for the Virtex-6 FPGA.

Table 4: Performance and Resource Utilization Benchmarks for Virtex-6 FPGA (XC6VLX130T-FFF1156-1)

Parameter Values		Device Resources		Performance
C_FIXED_SPEED	C_SPEED_100	Slice Flip-Flops	LUTs	F <sub>Max</sub> (MHz)
0	0	76	140	225
0	1	68	137	233
1	0	32	74	292
1	1	32	56	313

**Notes:**

1. These benchmark designs contain only the MII to RMI device with registered inputs/outputs without any additional logic. Benchmark numbers approach the performance ceiling rather than representing performance under typical user conditions.

Table 5 shows the MII to RMI core performance and device utilization benchmarks for the Spartan-6 FPGA.

Table 5: Performance and Resource Utilization Benchmarks for Spartan-6 FPGA (XC6SLX45T-FGG484-2)

Parameter Values		Device Resources			Performance
C_FIXED_SPEED	C_SPEED_100	Slices	Slice Flip-Flops	4-input LUTs	F <sub>Max</sub> (MHz)
0	0	56	140	111	139
0	1	56	137	109	144
1	0	28	74	56	207
1	1	27	56	44	212

**Notes:**

- These benchmark designs contain only the MII to RMI device with registered inputs/outputs without any additional logic. Benchmark numbers approach the performance ceiling rather than representing performance under typical user conditions.

Table 6 shows the MII to RMI core performance and device utilization benchmarks for the Virtex-5 FPGA.

Table 6: Performance and Resource Utilization Benchmarks for Virtex-5 FPGA (XC5VLX85-2-FF676)

Parameter Values		Device Resources		Performance
C_FIXED_SPEED	C_SPEED_100	Slice Flip-Flops	LUTs	F <sub>Max</sub> (MHz)
0	0	161	106	240
0	1	145	101	253
1	0	96	52	329
1	1	58	40	331

**Notes:**

- These benchmark designs contain only the MII to RMI device with registered inputs/outputs without any additional logic. Benchmark numbers approach the performance ceiling rather than representing performance under typical user conditions.

Table 7 shows the MII to RMI core performance and device utilization benchmarks for the Virtex-4 FPGA.

Table 7: Performance and Resource Utilization Benchmarks for Virtex-4 FPGA (XC4VLX80-11-FF1148)

Parameter Values		Device Resources			Performance
C_FIXED_SPEED	C_SPEED_100	Slices	Slice Flip-Flops	4-input LUTs	F <sub>Max</sub> (MHz)
0	0	144	183	132	283
0	1	135	167	128	239
1	0	97	131	165	288
1	1	60	76	46	300

**Notes:**

- These benchmark designs contain only the MII to RMI device with registered inputs/outputs without any additional logic. Benchmark numbers approach the performance ceiling rather than representing performance under typical user conditions.

## Specification Exceptions

None.

## References

These documents provide supplemental material useful with this product guide:

1. [DS580](#), *XPS Ethernet Lite Media Access Controller*
2. [UG814](#), *Vivado Design Suite Getting Started Guide*
3. IEEE Std. 802.3
4. *RMII Specification*, written by the RMII Consortium (version 1.0)

## Technical Support

Xilinx provides technical support at [www.xilinx.com/support](http://www.xilinx.com/support) for this LogiCORE IP product when used as described in the product documentation. Xilinx cannot guarantee timing, functionality, or support of product if implemented in devices that are not defined in the documentation, if customized beyond that allowed in the product documentation, or if changes are made to any section of the design labeled DO NOT MODIFY.

See the IDS Embedded Edition Derivative Device Support web page ([www.xilinx.com/ise/embedded/ddsupport.htm](http://www.xilinx.com/ise/embedded/ddsupport.htm)) for a complete list of supported derivative devices for this core.

## Licensing and Ordering Information

This Xilinx LogiCORE IP module is provided at no additional cost with the Xilinx Vivado Design Suite and ISE Design Suite Embedded Edition tools under the terms of the [Xilinx End User License](#).

Information about this and other Xilinx LogiCORE IP modules is available at the [Xilinx Intellectual Property](#) page. For information on pricing and availability of other Xilinx LogiCORE IP modules and tools, contact your [local Xilinx sales representative](#).

## Revision History

Date	Version	Revision
05/07/03	1.0	Initial release
07/09/03	1.2	Update for EDK Granite
01/09/04	1.3	Update family per CR 181443; update copyright date
02/06/04	1.4	Added IOB count and protocol wave diagrams
03/05/04	1.5	Added implementation constraints, changed synthesis to XST, changed several Overview items to N/A
03/16/04	1.6	Updated resource use tables
05/05/04	1.7	Added Virtex-4™ in supported families
08/19/04	1.8	Updated for Gmm; updated trademarks and supported device family listing
04/04/05	1.9	Updated for EDK 7.1.1 SP1; updated trademarks and supported device listing
08/24/05	2.0	Converted to new DS template; updated figures to Xilinx graphic standards
12/02/05	2.1	Added Spartan-3E to supported devices listing
06/29/06	2.2	Updated for Virtex-5 support
11/20/08	2.3	Added RMI Specification 1.0 support note
04/24/09	2.4	Replaced references to supported device families and tool names with hyperlink to PDF file.
12/21/09	2.5	Updated the core version and utilization matrix.
04/19/10	2.6	Updated to ISE 12.1; added support for Virtex-6 and Spartan-6 devices.
07/23/10	2.7	Updated to ISE 12.2.
06/22/11	2.8	Updated to ISE 13.2. Updated for Virtex-7 and Kintex-7.
07/25/12	3.0	Updated for Vivado and Zynq features with minor document updates for v14.2

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