



## Imperas Peripheral Model Guide

### Model Specific Information for national.ovpworld.org / 16550

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## Model Release Status

This model is released as part of OVP releases and is included in OVPworld packages. Please visit [OVPworld.org](http://OVPworld.org).

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## **1.0 Model Specific Information**

This document provides usage information for an Imperas OVP peripheral behavioral model.

The document is split into sections providing specific information for this peripheral, including any ports for connecting into a platform, registers, other component parts, and configuration options and general information for peripheral modeling with Imperas OVP.

### **1.1 Licensing**

Open Source Apache 2.0

### **1.2 Description**

16550 UART model

The serial input/output from the simulator is implemented using the Serial Device Support described in OVP BHM and PPM API Functions Reference, which describes the parameters that control how the model interacts with the host computer.

Interrupts and FIFOs are supported.

Registers are aligned on 1 byte boundaries.

### **1.3 Limitations**

Resolution of the baud rate is limited to the simulation time slice (aka quantum) size.

Values written to the MCR are ignored. Loopback mode is not supported.

The LSR is read-only. The model never sets the LSR 'Parity Error', 'Framing Error', 'Break Interrupt' or 'Error in RCVR FIFO' bits.

The MSR 'Data Set Ready' and 'Clear To Send' bits are set at reset and all other MSR bits are cleared. MSR bits will only be changed by writes to the MSR and values written to the Modem Status Register do not effect the operation of the model.

### **1.4 Reference**

PC16550D Universal Asynchronous Receiver/Transmitter with FIFOs datasheet  
(<http://www.ti.com/lit/ds/symlink/pc16550d.pdf>)

### **1.5 Location**

The 16550 peripheral model is located in an Imperas/OVP installation at the VLNV: national.ovpworld.org / peripheral / 16550 / 1.0.

## 2.0 Peripheral Instance Parameters

This model accepts the following parameters:

Table 1. Peripheral Parameters

Name	Type	Description
uart16450	bool	Run in 16450 mode (no FIFOs)
fifoSize	uns32	Size of fifos
refClkFreq	uns32	Frequency (in hertz) of reference clock rate used in baud rate calculation
simulatebaud	bool	Description Set to true to simulate baud delay determined by the Divisor Latch register value and reference clock frequency. Set to false to run without delay - next read data is made available immediately upon read of Receiver Buffer Register. Defaults to false
charmcode	bool	Description Set to true when the port is used to connect to a Telnet program and character mode is desired rather than the default Telnet line mode. When set to true a Telnet command sequence is sent at startup that configures the Telnet program into character mode. In addition null bytes are stripped from the data received.
console	bool	If specified, port number is ignored, and a console pops up automatically
client	bool	If true, model is a client and will connect to portnum. If false, model is a server and will listen on portnum.
portnum	uns32	If set, listen on, or connect to, this port. If set to zero in listen mode, allocate a port from the pool and listen on that.
hostname	string	Name (or IP address) of host to connect to. Valid if listen=true
infile	string	Name of file to use for device source
outfile	string	Name of file to write device output
portFile	string	If portnum was specified as zero, write the port number to this file when it's known
log	bool	If specified, serial output will go to simulator log
finishOnDisconnect	bool	If set, disconnecting the port will cause the simulation to finish
connectnonblocking	bool	If set, simulation can begin before the connection is made
xchars	uns32	Width of console in characters
ychars	uns32	Height of console in characters
record	string	Record external events into this file
replay	string	Replay external events from this file

## 3.0 Net Ports

This model has the following net ports:

Table 2. Net Ports

Name	Type	Must Be Connected	Description
reset_uart	input	F (False)	
intOut	output	F (False)	

## 4.0 Bus Slave Ports

This model has the following bus slave ports:

### 4.1 Bus Slave Port: *bport1*

Table 3. Bus Slave Port: *bport1*

Name	Size (bytes)	Must Be Connected	Description
bport1	0x8	T (True)	

Table 4. Bus Slave Port: *bport1* Registers:

Name	Offset	Width (bits)	Description	R/W	is Volatile
ab_rbr_dll	0x0	8	UART Receiver Buffer Register/Divisor Latch Low Read (LCR.DLAB=1)		
ab_thr_dll	0x0	8	UART Transmitter Holding Register/Divisor Latch Low Write (LCR.DLAB=1)		
ab_ier_dlh	0x1	8	UART Interrupt Enable Register/Divisor Latch High (LCR.DLAB=1)		
ab_iir	0x2	8	UART Interrupt Identity Register		
ab_fcr	0x2	8	UART FIFO Control Register		
ab_lcr	0x3	8	UART Line Control Register		
ab_mcr	0x4	8	UART MODEM Control Register		
ab_lsr	0x5	8	UART Line Status Register		
ab_msr	0x6	8	UART MODEM Status Register		
ab_scr	0x7	8	UART Scratch Register		

## 5.0 Platforms that use this peripheral component

Peripheral components can be used in many different platforms, including those developed by Imperas or by other users of OVP. You can use this peripheral in your own platforms.

Table 5. Publicly available platforms using peripheral '16550'

Platform Name	Vendor
HeteroArmNucleusMIPSLinux	imperas.ovpworld.org
Or1kUclinux	imperas.ovpworld.org
MipsMalta	mips.ovpworld.org
MipsMalta	mips.ovpworld.org
virtio	riscv.ovpworld.org
Hetero_ArmIntegratorCP_XilinxMicroBlaze	imperas.ovpworld.org
Hetero_ArmVersatileExpress_XilinxMicroBlaze	imperas.ovpworld.org

## 6.0 Peripheral components in the library

Table 6. Publicly available Imperas/OVP peripheral models (227 models)

Peripheral	Peripheral	Peripheral
national.ovpworld.org/16550_4bytes	nxp.ovpworld.org/iMX6_Analog	nxp.ovpworld.org/iMX6_CCM
nxp.ovpworld.org/iMX6_GPC	nxp.ovpworld.org/iMX6_GPIO	nxp.ovpworld.org/iMX6_GPT
nxp.ovpworld.org/iMX6_MMDC	nxp.ovpworld.org/iMX6_SDHC	nxp.ovpworld.org/iMX6_SRC
nxp.ovpworld.org/iMX6_UART	nxp.ovpworld.org/iMX6_WDOG	ovpworld.org/Alpha2x16Display
ovpworld.org/DynamicBridge	ovpworld.org/FlashDevice	ovpworld.org/ledRegister
ovpworld.org/SerInt	ovpworld.org/SimpleDma	ovpworld.org/switchRegister
ovpworld.org/temperatureSensor	ovpworld.org/trap	ovpworld.org/trap4K
ovpworld.org/vEthernet_Bridge	ovpworld.org/VirtioBlkMMIO	ovpworld.org/VirtioNetMMIO
philips.ovpworld.org/ISP1761	renesas.ovpworld.org/adc	renesas.ovpworld.org/bcu
renesas.ovpworld.org/brg	renesas.ovpworld.org/can	renesas.ovpworld.org/can
renesas.ovpworld.org/clkgen	renesas.ovpworld.org/crc	renesas.ovpworld.org/csib
renesas.ovpworld.org/csie	renesas.ovpworld.org/dma	renesas.ovpworld.org/intc
renesas.ovpworld.org/memc	renesas.ovpworld.org/rng	renesas.ovpworld.org/taa
renesas.ovpworld.org/tms	renesas.ovpworld.org/tmt	renesas.ovpworld.org/uartc
renesas.ovpworld.org/UPD70F3441Logic	riscv.ovpworld.org/CLINT	riscv.ovpworld.org/PLIC
riscv.ovpworld.org/SmartLoaderRV64Linux	safePower.ovpworld.org/node	safePower.ovpworld.org/NostrumNode
safePower.ovpworld.org/ring_oscillator	safePower.ovpworld.org/TTElNode	sifive.ovpworld.org/artyo
sifive.ovpworld.org/DDRCTL	sifive.ovpworld.org/gpio	sifive.ovpworld.org/MSEL
sifive.ovpworld.org/PLIC	sifive.ovpworld.org/PRCI	sifive.ovpworld.org/pwm
sifive.ovpworld.org/spi	sifive.ovpworld.org/teststatus	sifive.ovpworld.org/UART
smc.ovpworld.org/LAN9118	smc.ovpworld.org/LAN91C111	ti.ovpworld.org/tca6416a
ti.ovpworld.org/UartInterface	ti.ovpworld.org/ucd9012a	ti.ovpworld.org/ucd9248
vendor.com/fifo	xilinx.ovpworld.org/axi-gpio	xilinx.ovpworld.org/axi-intc
xilinx.ovpworld.org/axi-pcie	xilinx.ovpworld.org/axi-timer	xilinx.ovpworld.org/logicore-fit
xilinx.ovpworld.org/mdm	xilinx.ovpworld.org/mpmc	xilinx.ovpworld.org/xps-gpio
xilinx.ovpworld.org/xps-iic	xilinx.ovpworld.org/xps-intc	xilinx.ovpworld.org/xps-ll-temac
xilinx.ovpworld.org/xps-mch-emc	xilinx.ovpworld.org/xps-sysace	xilinx.ovpworld.org/xps-timer
xilinx.ovpworld.org/xps-uartlite	xilinx.ovpworld.org/zynq_7000-can	xilinx.ovpworld.org/zynq_7000-ddrc
xilinx.ovpworld.org/zynq_7000-devcfg	xilinx.ovpworld.org/zynq_7000-dmac	xilinx.ovpworld.org/zynq_7000-gpio
xilinx.ovpworld.org/zynq_7000-iic	xilinx.ovpworld.org/zynq_7000-ocm	xilinx.ovpworld.org/zynq_7000-qos301
xilinx.ovpworld.org/zynq_7000-qspi	xilinx.ovpworld.org/zynq_7000-sdio	xilinx.ovpworld.org/zynq_7000-slcr
xilinx.ovpworld.org/zynq_7000-spi	xilinx.ovpworld.org/zynq_7000-swdt	xilinx.ovpworld.org/zynq_7000-ttc
xilinx.ovpworld.org/zynq_7000-tz_GPVsecurity	xilinx.ovpworld.org/zynq_7000-tz_security	xilinx.ovpworld.org/zynq_7000-usb
altera.ovpworld.org/dw-apb-timer	altera.ovpworld.org/dw-apb-uart	altera.ovpworld.org/IntervalTimer32Core
altera.ovpworld.org/IntervalTimer64Core	altera.ovpworld.org/JtagUart	altera.ovpworld.org/PerformanceCounterCore
altera.ovpworld.org/RSTMGR	altera.ovpworld.org/SystemIDCore	altera.ovpworld.org/Uart
amd.ovpworld.org/79C970	andes.ovpworld.org/ATCUART100	andes.ovpworld.org/NCEPLIC100
andes.ovpworld.org/NCEPLMT100	arm.ovpworld.org/AaciPL041	arm.ovpworld.org/CompactFlashRegs
arm.ovpworld.org/CoreModule9x6	arm.ovpworld.org/DebugLedAndDipSwitch	arm.ovpworld.org/DMemCtrlPL341
arm.ovpworld.org/IcpControl	arm.ovpworld.org/IcpCounterTimer	arm.ovpworld.org/IntICP
arm.ovpworld.org/IntICP	arm.ovpworld.org/KbPL050	arm.ovpworld.org/L2CachePL310
arm.ovpworld.org/LcdPL110	arm.ovpworld.org/MmcPL181	arm.ovpworld.org/RtcPL031
arm.ovpworld.org/SerBusDviRegs	arm.ovpworld.org/SmartLoaderArm64Linux	arm.ovpworld.org/SmartLoaderArmLinux

arm.ovpworld.org/SMemCtrlPL354	arm.ovpworld.org/SysCtrlSP810	arm.ovpworld.org/TimerSP804
arm.ovpworld.org/TzpcBP147	arm.ovpworld.org/UartPL011	arm.ovpworld.org/VexpressSysRegs
arm.ovpworld.org/WdtSP805	atmel.ovpworld.org/AdvancedInterruptController	atmel.ovpworld.org/ParallelIOController
atmel.ovpworld.org/PowerSaving	atmel.ovpworld.org/SpecialFunction	atmel.ovpworld.org/TimerCounter
atmel.ovpworld.org/UsartInterface	atmel.ovpworld.org/WatchdogTimer	cadence.ovpworld.org/gem
cadence.ovpworld.org/uart	cirrus.ovpworld.org/GD5446	freescale.ovpworld.org/KinetisADC
freescale.ovpworld.org/KinetisAIPS	freescale.ovpworld.org/KinetisAXBBS	freescale.ovpworld.org/KinetisCAN
freescale.ovpworld.org/KinetisCMP	freescale.ovpworld.org/KinetisCMT	freescale.ovpworld.org/KinetisCRC
freescale.ovpworld.org/KinetisDAC	freescale.ovpworld.org/KinetisDDR	freescale.ovpworld.org/KinetisDMA
freescale.ovpworld.org/KinetisDMAC	freescale.ovpworld.org/KinetisDMAMUX	freescale.ovpworld.org/KinetisENET
freescale.ovpworld.org/KinetisEWM	freescale.ovpworld.org/KinetisFB	freescale.ovpworld.org/KinetisFMC
freescale.ovpworld.org/KinetisFTFE	freescale.ovpworld.org/KinetisFTM	freescale.ovpworld.org/KinetisGPIO
freescale.ovpworld.org/KinetisI2C	freescale.ovpworld.org/KinetisI2S	freescale.ovpworld.org/KinetisLLWU
freescale.ovpworld.org/KinetisLPTMR	freescale.ovpworld.org/KinetisMCG	freescale.ovpworld.org/KinetisMPU
freescale.ovpworld.org/KinetisNFC	freescale.ovpworld.org/KinetisOSC	freescale.ovpworld.org/KinetisPDB
freescale.ovpworld.org/KinetisPIT	freescale.ovpworld.org/KinetisPMC	freescale.ovpworld.org/KinetisPORT
freescale.ovpworld.org/KinetisRCM	freescale.ovpworld.org/KinetisRFSYS	freescale.ovpworld.org/KinetisRFVBAT
freescale.ovpworld.org/KinetisRNG	freescale.ovpworld.org/KinetisRTC	freescale.ovpworld.org/KinetisSDHC
freescale.ovpworld.org/KinetisSIM	freescale.ovpworld.org/KinetisSMC	freescale.ovpworld.org/KinetisSPI
freescale.ovpworld.org/KinetisTSI	freescale.ovpworld.org/KinetisUART	freescale.ovpworld.org/KinetisUSB
freescale.ovpworld.org/KinetisUSBDCD	freescale.ovpworld.org/KinetisUSBHS	freescale.ovpworld.org/KinetisVREF
freescale.ovpworld.org/KinetisWDOG	freescale.ovpworld.org/Uart	freescale.ovpworld.org/VybridADC
freescale.ovpworld.org/VybridANADIG	freescale.ovpworld.org/VybridCCM	freescale.ovpworld.org/VybridDMA
freescale.ovpworld.org/VybridGPIO	freescale.ovpworld.org/VybridI2C	freescale.ovpworld.org/VybridLCD
freescale.ovpworld.org/VybridQUADSPI	freescale.ovpworld.org/VybridSDHC	freescale.ovpworld.org/VybridSPI
freescale.ovpworld.org/VybridUART	freescale.ovpworld.org/VybridUSB	imperas.ovpworld.org/frameBuffer
imperas.ovpworld.org/uart	imperas.ovpworld.org/usecCounter	intel.ovpworld.org/82077AA
intel.ovpworld.org/82371EB	intel.ovpworld.org/8253	intel.ovpworld.org/8259A
intel.ovpworld.org/NorFlash48F4400	intel.ovpworld.org/PciIDE	intel.ovpworld.org/PciPM
intel.ovpworld.org/PciUSB	intel.ovpworld.org/Ps2Control	marvell.ovpworld.org/GT6412x
maxim.ovpworld.org/max673x	microsemi.ovpworld.org/CoreUARTapb	mips.ovpworld.org/16450C
mips.ovpworld.org/MaltaFPGA	mips.ovpworld.org/SmartLoaderLinux	motorola.ovpworld.org/MC146818
national.ovpworld.org/16450	national.ovpworld.org/16550	



## 7.0 General Information on Peripheral Models

This document provides usage information for an Imperas OVP peripheral behavioral model.

The document is split into sections providing specific information for this peripheral, including any ports for connecting into a platform, registers etc. and configuration options and general information for peripheral modeling with Imperas OVP.

### 7.1 Background

Imperas OVP simulation technology enables very high performance simulation, debug and analysis of platforms containing multiple processors and peripheral models. The technology is designed to be extensible: you can create new models of processors, peripherals and other platform components using interfaces and libraries defined by OVP.

The peripheral models created using the OVP APIs run on the Peripheral Simulation Engine (PSE).

The model is typically written in C and compiled into an executable for the PSE processor architecture. The model is compiled for speed of execution and to protect IP. It is dynamically loaded by the simulator at run time.

## 8.0 Building peripherals easily with Imperas iGen

To aid with model creation, Imperas products include iGen, a model generation tool. iGen takes the laborious and error-prone task of constructing the various hardware model and software element files required for a typical model, and automates this process. iGen creates the needed C files. iGen also creates the C++ SystemC TLM2 interface files needed to run peripheral models in SystemC simulations.

iGen takes as input a simple script specification that includes device internals such as registers and memories, port information, component descriptors, and other elements. iGen then builds the C code model files and user editable templates. These include model frameworks with registers, function calls, memory map, and other items. It ensures that all component parts of the model are well-structured using best practices, and are consistent throughout the files, thus eliminating a common source of errors.

More information on iGen can be found: [imperas.com/products](http://imperas.com/products).

## 9.0 Peripheral model internals

Each instance of a peripheral model runs on its own virtual machine with an address space large enough for the model. This processor (the PSE) and its memory are separate from any processors, memories and buses in the platform being simulated; they exist only to execute the code of the peripheral model.

Interception of functions defined in the peripheral model allows the use of features of the host system in the

implementation of the behavior of a peripheral. As an example, a real platform might contain a video display device. When simulating this system, it is generally more convenient not to simulate the complete video display device but to use a video package available on the host machine, such as SDL, and to use this to render to the host display. Also models of uarts, ethernet devices and USB components can make use of the host PC resources during simulation, to allow, for example, a simulation to browse the real internet, or the simulation to connect to a real USB device.

## 10.0 Parts of peripheral models

### *10.1 Configuring the Peripheral Instance with Parameters*

A peripheral can include the behaviour of several configurations. These are controlled when the peripheral is instanced in the platform by setting parameters defined on the peripheral.

### *10.2 Net Ports*

Peripherals may be connected to other peripherals or processors with signal wires (nets). These can be used to act as interrupt signals or used to control behavior between peripherals.

The wires are created in the platform as nets and this net is connected into the peripheral using a net port.

### *10.3 Bus master ports*

A bus master port initiates (and controls the address of) a bus cycle. Bus cycles are generated by behavioral code within the peripheral model.

### *10.4 Bus slave ports*

A peripheral can be defined as having several bus slave ports. The bus slave ports can be split into several address blocks. Each address block be either local memory or memory mapped registers. Both of these can have associated callback functions. A memory mapped register can also be defined as specific read/write access, whether it is volatile, and also whether it is associated with a reset pin and mask. A memory mapped register can also have specific bit fields defined.

### *10.5 Packetnets*

A peripheral can be defined as being connected to packetnet ports. A packetnet is used to model packet based communication such as Ethernet, CAN bus or GSM. A packetnet is created in a platform, then connected to packetnet ports on model instances. A packetnet can have many connections, each able to send or receive packets. A packetnet is used as an efficient method of communication within OVP models.

For more information on modeling with packetnets, please see the peripheral modeling documentation: [OVP\\_Peripheral\\_Modeling\\_Guide.pdf](#), [OVPSim\\_and\\_CpuManager\\_User\\_Guide.pdf](#) and the example: [\\$IMPERAS\\_HOME/Examples/Models/Peripherals/packetnet](#).

## 11.0 More information (documentation) on peripheral models and modeling

More information on modeling and APIs can be found at: [OVPworld.org/technology\\_apis](http://OVPworld.org/technology_apis).

Specifics on modeling peripherals can be found: [OVP\\_Peripheral\\_Modeling\\_Guide.pdf](#).

A full list of the currently available OVP documentation is available: [OVPworld.org/documentation](#).

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