DriverLINX

Counter/Timer Programming Guide

KEITHLEY

DriverLINX Counter/Timer Programming Guide

SST 08-0101-1

Contents

Preface

Software License and Software Disclaimer of Warranty

This is a legal document which is an agreement between you, the Licensee, and Scientific Software Tools, Inc. By opening this sealed diskette package, Licensee agrees to become bound by the terms of this Agreement, which include the Software License and Software Disclaimer of Warranty.

This Agreement constitutes the complete Agreement between Licensee and Scientific Software Tools, Inc. If Licensee does not agree to the terms of this Agreement, do not open the diskette package. Promptly return the unopened diskette package and the other items (including written materials, binders or other containers, and hardware, if any) that are part of this product to Scientific Software Tools, Inc. for a full refund. No refunds will be given for products that have opened disk packages or missing components.

Licensing Agreement

Copyright. The software and documentation is owned by Scientific Software Tools, Inc. and is protected by both United States copyright laws and international treaty provisions. Scientific Software Tools, Inc. authorizes the original purchaser only (Licensee) to either (a) make one copy of the software solely for backup or archival purposes, or (b) transfer the software to a single hard disk only. The written materials accompanying the software may not be duplicated or copied for any reason.

Trade Secret. Licensee understands and agrees that the software is the proprietary and confidential property of Scientific Software Tools, Inc. and a valuable trade secret. Licensee agrees to use the software only for the intended use under this License, and shall not disclose the software or its contents to any third party.

Copy Restrictions. The Licensee may not modify or translate the program or related documentation **without the prior written consent of Scientific Software Tools, Inc.** All modifications, adaptations, and merged portions of the software constitute the software licensed to the Licensee, and the terms and conditions of this agreement apply to same. Licensee may not distribute copies, including electronic transfer of copies, of the modified, adapted or merged software or accompanying written materials to others. Licensee agrees not to reverse engineer, decompile or disassemble any part of the software.

Unauthorized copying of the software, including software that has been modified, merged, or included with other software, or of the written materials is expressly forbidden. Licensee may not rent, transfer or lease the software to any third parties. Licensee agrees to take all reasonable steps to protect Scientific Software Tools' software from theft, disclosure or use contrary to the terms of the License.

License. Scientific Software Tools, Inc. grants the Licensee only a non-exclusive right to use the serialized copy of the software on a single terminal connected to a single computer. The Licensee may not network the software or use it on more than one computer or computer terminal at the same time.

Term. This License is effective until terminated. This License will terminate automatically without notice from Scientific Software Tools, Inc. if Licensee fails to comply with any term or condition of this License. The Licensee agrees upon such termination to return or destroy the written materials and all copies of the software. The Licensee may terminate the agreement by returning or destroying the program and documentation and all copies thereof.

Limited Warranty

Scientific Software Tools, Inc. warrants that the software will perform substantially in accordance with the written materials and that the program disk, instructional manuals and reference materials are free from defects in materials and workmanship under normal use for 90 days from the date of receipt. All express or implied warranties of the software and related materials are limited to 90 days.

Except as specifically set forth herein, the software and accompanying written materials (including instructions for use) are provided "as is" without warranty of any kind. Further, Scientific Software Tools, Inc. does not warrant, guarantee, or make any representations regarding the use, or the results of the use, of the software or written materials in terms of correctness, accuracy, reliability, currentness, or otherwise. The entire risk as to the results and performance of the software is assumed by Licensee and not by Scientific Software Tools, Inc. or its distributors, agents or employees.

EXCEPT AS SET FORTH HEREIN, THERE ARE NO OTHER WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, WITH RESPECT TO THE SOFTWARE, THE ACCOMPANYING WRITTEN MATERIALS, AND ANY ACCOMPANYING HARDWARE.

Remedy. Scientific Software Tools' entire liability and the Licensee's exclusive remedy shall be, at Scientific Software Tools' option, either (a) return of the price paid or (b) repair or replacement of the software or accompanying materials. In the event of a defect in material or workmanship, the item may be returned within the warranty period to Scientific Software Tools for a replacement without charge, provided the licensee previously sent in the limited warranty registration card to Scientific Software Tools, Inc., or can furnish proof of the purchase of the program. This remedy is void if failure has resulted from accident, abuse, or misapplication. Any replacement will be warranted for the remainder of the original warranty period.

NEITHER SCIENTIFIC SOFTWARE TOOLS, INC. NOR ANYONE ELSE WHO HAS BEEN INVOLVED IN THE CREATION, PRODUCTION, SALE OR DELIVERY OF THIS PRODUCT SHALL BE LIABLE FOR ANY DIRECT, INDIRECT, CONSEQUENTIAL, OR INCIDENTAL DAMAGES (INCLUDING DAMAGES FOR LOSS OF BUSINESS PROFITS, BUSINESS INTERRUPTION, LOSS OF BUSINESS INFORMATION AND THE LIKE) ARISING OUT OF THE USE OF OR THE INABILITY TO USE SUCH PRODUCT EVEN IF SCIENTIFIC SOFTWARE TOOLS HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. BECAUSE SOME JURISDICTIONS DO NOT ALLOW THE EXCLUSION OR LIMITATION OF LIABILITY FOR CONSEQUENTIAL OR INCIDENTAL DAMAGES, OR LIMITATIONS ON DURATION OF AN IMPLIED WARRANTY, THE ABOVE LIMITATIONS MAY NOT APPLY TO LICENSEE.

This agreement is governed by the laws of the Commonwealth of Pennsylvania.

About DriverLINX

Welcome to DriverLINX® for Microsoft® Windows™, the high-performance real-time data-acquisition device drivers for Windows application development.

DriverLINX is a language- and hardware-independent application-programming interface designed to support hardware manufacturers' high-speed analog, digital, and counter/timer data-acquisition boards in Windows. DriverLINX is a multi-user and multitasking data-acquisition resource manager providing more than 100 services for foreground and background data acquisition tasks.

Included with your DriverLINX package are the following items:

- The DriverLINX DLLs and drivers supporting your data-acquisition hardware
- Learn DriverLINX, an interactive learning and demonstration program for DriverLINX that includes a Digital Storage Oscilloscope
- Source code for the sample programs
- The DriverLINX Application Programming Interface files for your compiler
- DriverLINX On-line Help System
- *DriverLINX 4.0 Installation and Configuration Guide*
- *DriverLINX Technical Reference Manual*
- Supplemental Documentation on DriverLINX and your data acquisition hardware

About This Programming Guide

The purpose of this manual is to help you quickly learn to program DriverLINX for counter/timer operations with your hardware.

- For help installing and configuring your hardware and DriverLINX, please see the hardware manuals that accompanied your board and the *DriverLINX 4.0 Installation and Configuration Guide* for your version of Windows.
- For more information on the DriverLINX API, please see the on-line *DriverLINX Technical Reference Manual*.
- For additional help programming your board, please examine the source code examples on the Distribution Disks.

This manual is divided into the following chapters:

Why Use a Counter/Timer Device Driver

Brief discussion of why modern operating systems require device drivers.

Introducing DriverLINX

Presents a quick overview of DriverLINX's hardware and programming model.

Counter/Timers and DriverLINX

Describes how DriverLINX's hardware model supports counter/timer boards.

Programming Counter/Timers with DriverLINX

Explains how to program counter/timer tasks.

Using Task-Oriented Functions

Describes counter/timer functions that DriverLINX defines with a task orientation rather than a hardware orientation.

Hardware Reference

Describes Intel 8254, KPCI-3140 and Am9513 operating modes and how they map onto the DriverLINX programming model.

Conventions Used in This Manual

The following notational conventions are used in this manual:

- A round bullet identifies itemized lists (•).
- Numbered lists indicate a step-by-step procedure.
- DriverLINX Application Programming Interface and Windows macro and function names are set in bold when mentioned in the text.
- **DriverLINX** indicates the exported function name of the device driver DLL while DriverLINX indicates the product as a whole.
- DriverLINX Application Programming Interface identifiers, menu items, and Dialog Box names are italicized when mentioned in the text.
- *Italics* are used for emphasis.
- Source code and data structure examples are displayed in Courier typeface and bounded by a box with a single line.

```
Code
```

- A box with a double line bound tables of information.

Tables

Concept

- Important concepts and notes are printed in the left margin.

Why Use a Counter/Timer Device Driver

Using Direct Hardware I/O

Most counter/timer devices are simple devices to program. For years most application developers wrote directly to the I/O hardware using the CPU's I/O instructions (inp and outp) or using Peek and Poke statements in Basic. This was simple, fast, and efficient and required a minimal learning curve.

Under Windows 3.x, C/C++ developers could use these same techniques for most ports despite Microsoft's strong recommendation against doing so. Visual Basic programmers, however, found that Microsoft had removed all direct I/O statements from the language, but they quickly discovered they could replace the missing statements with calls to simple DLLs.

With the arrival of Windows NT, direct hardware I/O in user applications is not physically possible. Hardware I/O in DOS and Win16 apps may appear to execute, but the CPU never actually executes the I/O instructions. In Win32 apps hardware I/O instructions generate a "privileged instruction exception" and terminate the offending app.

To perform user-level I/O in Windows NT and future versions of Windows 95, the operating system requires that applications communicate with the hardware using a device driver. Modern device drivers are effectively trusted operating system extensions that have more privileges than ordinary user-mode applications, DLLs, and services.

Advantages of Device Drivers

Using device drivers to control hardware offers an application in a modern multitasking, multithreaded operating system several advantages and one major disadvantage. The application advantages of the device driver model are

- hardware-independent access to boards belonging to a class of devices,
- resource sharing of a single physical device among multiple applications and/or threads,

- resource arbitration when multiple device users contend for the same hardware resources, and
- system security either at the logical level of authorized device users or at the physical level of preventing misuse of a device.

The main disadvantage of the device driver model is the extra overhead the system requires to communicate device requests between the application, the device driver, and the hardware. **For device requests, such as acquiring a million data samples in one request, the overhead is negligible, but for acquiring one sample using a million separate requests, the time penalty is significant.** For this reason, developers must often redesign the protocols and algorithms that worked well in a single-tasking OS, such as DOS, for use in a multitasking system, such as Windows NT.

Introducing DriverLINX

About DriverLINX

The DriverLINX Distribution Disks contain many sample programs for a variety of hardware devices. Many samples will not work with counter/timer devices.

Welcome to DriverLINX for Microsoft Windows. DriverLINX is a language and hardware-independent, high-performance, real-time, data-acquisition device driver for 16 and 32-bit Windows 3.x, Windows 95 and Windows NT. DriverLINX supports an abstract hardware model for generalized data-acquisition hardware that includes analog and digital I/O as well as counter/timer functions.

This chapter briefly surveys the DriverLINX hardware and programming model. The on-line *DriverLINX Technical Reference Manual* included with the DriverLINX package is the complete, board-independent specification for the abstract DriverLINX hardware model. Whether or not you are familiar with DriverLINX programming, this guide will ease your learning curve by focusing on just the counter/timer subsystem programming model.

DriverLINX Hardware Model

DriverLINX Driver

Each DriverLINX driver supports one or more models of a device series in a manufacturer's product line. You can control multiple products from different series by opening several DriverLINX drivers. You can program each product using different "Service Requests" for each overlapping data-acquisition task.

Logical Devices

A single DriverLINX driver can support multiple boards from its list of supported models. During configuration, you assign each physical device a Logical Device number that you use to identify a particular board to DriverLINX. At run time, applications can determine the manufacturer, model name, I/O address, and hardware resources of a Logical Device by consulting DriverLINX's Logical Device Descriptor.

Logical Subsystems

DriverLINX treats *all* data-acquisition devices uniformly as abstract hardware consisting of seven possible subsystems.

- **DEVICE**—the physical hardware considered as a whole.
- **AI** (Analog Input)—the A/D converters, multiplexers, and associated hardware.
- **AO** (Analog Output)—the D/A converters and associated hardware.
- **DI** (Digital Input)—the digital input ports and associated hardware.
- **DO** (Digital Output)—the digital output ports and associated hardware.
- **CT** (Counter/Timer)—the counter/timer channels and associated hardware.

DriverLINX's Logical Device Descriptor contains properties specifying which Logical Subsystems are available for a particular device. Counter/timer boards always support the **DEVICE** and **CT** subsystems, and some boards support additional subsystems, such as **DI** and **DO**.

Logical Channels

The subsystems, except **DEVICE**, consist of one or more data channels known as Logical Channels. Usually a Logical Channel corresponds to one hardware channel, but, for some boards, DriverLINX may use multiple Logical Channel numbers to access a group of hardware channels using different data widths. DriverLINX records the number of Logical Channels and their capabilities in the Logical Device Descriptor.

DriverLINX Programming Model

Programming DriverLINX for data-acquisition tasks differs from the approach you may have used previously. Most vendors' data-acquisition packages consist of thick documents describing hundreds of hardware-specific calls to configure and program a data-acquisition board. DriverLINX, in contrast, uses a board-independent list of properties to specify the parameters for a data-acquisition task.

All data-acquisition tasks in DriverLINX use the same, simple three-step protocol:

1. Decide how you want to acquire data.
2. Specify your task by setting the properties of an object or data structure known as the Service Request.
3. Pass the Service Request to DriverLINX, which sets up the hardware and acquires the data for you.

The power of the Service Request approach is that you use the same structure for *all* data-acquisition tasks on *any* supported hardware. Once you understand how to program one type of device, you can use that knowledge to program any other supported device.

To notify an application of the progress or error conditions detected during a data-acquisition task, DriverLINX sends the application a series of messages just as Windows sends messages to an application's message loop. This feature allows an

application to overlap data processing with data acquisition and easily synchronize the two activities.

Most data-acquisition drivers manage a hardware board exclusively for one application. DriverLINX, however, manages the subsystems of a hardware board as a shared resource that multiple applications or threads can share. If your hardware board has the necessary features, DriverLINX supports running multiple, independent tasks concurrently on one board.

Logical Device Descriptors

DriverLINX does not require that applications reference or use the LDD to program data-acquisition tasks.

For writing hardware-independent applications, you may need to know the hardware specifications of the board your program is controlling. DriverLINX makes this information available to your program with another device-independent data structure known as the Logical Device Descriptor (LDD). The LDD contains information about number and types of data channels on the board, the allowed operating modes and commands, and many other details. For more information, see the on-line *DriverLINX Technical Reference Manual*.

Service Requests

The on-line DriverLINX Technical Reference Manual defines the DriverLINX Specification for all data-acquisition boards.

The most important DriverLINX concept to understand is the Service Request. This is the object, data structure, or form that you use to specify *all* data-acquisition tasks. **As much as is possible, DriverLINX treats all data-acquisition tasks as similar using the same concepts and properties to define each possible task.**

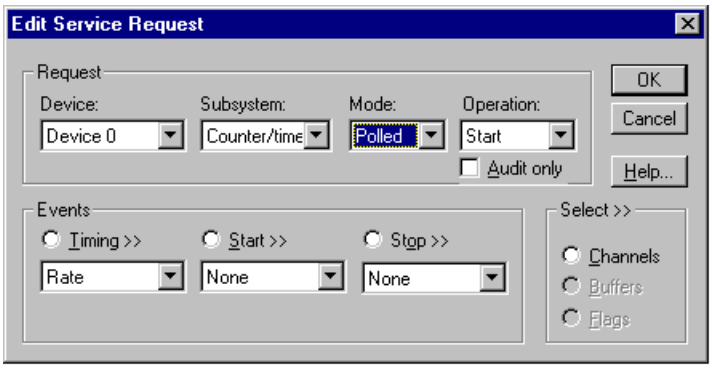
Using DriverLINX for a specific board requires learning just the supported properties for the board.

The key to learning how to specify a Service Request is first learning the major groups of a Service Request, and then learning the properties for each group.

A Service Request consists of four major property groups:

- **Request Group**—specifies the target Logical Device and Logical Subsystem of a task and the data-acquisition mode and operation to perform.
- **Events Group**—specifies how DriverLINX should time or pace data acquisition, when DriverLINX should start acquisition, and when it should end.
- **Select Group**—specifies the Logical Channels to acquire and the number and length of data buffers to acquire.
- **Results Group**—DriverLINX uses these properties to return result codes and single data values.

You can fill out Service Requests either interactively using the *Edit Service Request* Property page in DriverLINX or programmatically by assigning values to the required properties in each group.



C/C++ Interface

If you are using C/C++, the Service Request is a C data structure type definition. Create an instance of the data structure, set all fields to zero, and then assign the proper values to each needed property in the groups. After setting up the Service Request, pass the address of the Service Request to DriverLINX for execution. DriverLINX will report information about the task back to the application using Windows messages.

Control Interface

If you are using the Visual Basic custom control (VBX) or ActiveX (OLE or OCX) version of DriverLINX, the Service Request is an instance of the control object on your form or dialog. Assign the proper values to the needed properties for your task. Then tell DriverLINX to execute the Service Request by calling the *Refresh* method for the control. DriverLINX will report information about the task back to the application using control events.

Summary

DriverLINX provides a hardware-independent, abstract model of data-acquisition hardware consisting of seven possible Logical Subsystems. Each Logical Subsystem treats data-acquisition tasks as conceptually similar. Developers program data-acquisition tasks by setting up the properties in the Request, Event, and Select Groups of a Service Request.

The on-line *DriverLINX Technical Reference Manual* defines the DriverLINX Specification for all data-acquisition boards. Using DriverLINX for a particular board requires learning the supported properties for the hardware.

Counter/Timers and DriverLINX

Counter/Timer Hardware Description

Most counter/timer boards use either the Intel 8254 Programmable Interval Timer or the AMD Am9513 System Timing Controller. The Intel 8254 is a much simpler device than the Am9513 chip, and the 8254 has limited capabilities without external circuitry and connections. Most vendors use the 8254 for clock generation on data-acquisition devices, but, for stand-alone counter/timer devices, they usually use the more complex Am9513 chip or proprietary chips as in the Keithley KPCI-3140 (and the compatible KPCI-3100 Series).

The DriverLINX Counter/Timer programming model supports diverse hardware using a common programming model. Although the programming model is common, developers should understand the inherent hardware differences among counter/timer chips if they need to write applications to support different counter/timers. The following sections present an overview of hardware features of these chips.

Intel 8254

The Intel 8254 provides three 16-bit timing channels per chip that support six pulse and frequency generation modes. The Intel 8254 is capable of simple event counting, rate and square wave generation, one-shot, and strobe applications.

The following table describes the six operation modes and variations of the Intel 8254 counter/timer chip. For a detailed description of these modes, see “8254 Operating Modes” on page 113.

Mode	Description
0	Event counting
1	Hardware retriggerable one-shot
2	Rate generator
3	Square wave generator
4	Software triggered strobe
5	Retriggerable hardware triggered strobe

Table 1 Designations for 8254 Counter/Timer Modes

Without external circuitry, however, the Intel 8254 does not support selectable clock sources, gating control, or output polarity. The effect of the gate input on counting is a function of the selected mode. The 8254 has no built-in frequency prescaler and only counts in binary.

For more information, see the *Intel 8254 Programmable Interval Timer* data sheet and your counter/timer hardware User's Guide.

KPCI-3140 Counter/Timer Chip

The counter/timer chip in the Keithley KPCI-3140 and KPCI-3100 Series provides four 16-bit timing channels per chip that support 3 pulse and frequency generation modes. In addition, the chip has two 24-bit counters but the only counter/timer function they can perform is to pace interrupt mode tasks.

The following table describes the three operation modes of the KPCI-3140 counter/timer chip. For a detailed description of these modes, see "KPCI-3140 Operating Modes" on page 116.

Mode	Description
0	Non-retriggerable One-shot
1	Retriggerable One-shot
2	Continuous Increment

Table 2 Designations for KPCI-3140 Counter/Timer Modes

Am9513

The Am9513 provides five 16-bit timing channels per chip that support 19 pulse and frequency generation modes. In addition, the Am9513 supports a variety of software options to electronically interconnect counter channels and to program outputs. The Am9513 allows software to select 16 counting sources and 5 output modes independent of the chip's operating mode. This chip has five built-in frequency prescalers and can count in either binary or binary coded decimal (BCD) modes. When using the prescalers in binary mode, each counter channel has an effective dynamic range of 32-bits.

The following table describes the 19 operation modes of the Am9513 and AMD's letter designation for each mode. For a detailed description of these modes, see "Am9513 Operating Modes" on page 117.

Mode	Description
A	Software triggered **Strobe** with no hardware gating
B	Software triggered **Strobe** with level gating
C	Hardware triggered **Strobe**
D	**Rate Generator** with no hardware gating
E	**Rate Generator** with level gating
F	Non-retriggerable **One-Shot**
G	Software triggered delayed **Pulse** one-shot
H	Software triggered delayed **Pulse** one-shot with hardware gating

Mode	Description
I	Hardware triggered delayed **Pulse** strobe
J	**Variable Duty Cycle** rate generator with no hardware gating
K	**Variable Duty Cycle** rate generator with level gating
L	Hardware triggered delayed **Pulse** one-shot
N	Software triggered **Strobe** with level gating and hardware retriggering
O	Software triggered **Strobe** with edge gating and hardware retriggering
Q	**Rate Generator** with synchronization
R	Retriggerable **One-Shot**
S	Delayed **Pulse** one-shot with level-selected reloading
V	**Frequency-Shift Keying**
X	**Rate Generator** with edge gating

Table 3 Letter Designations for Am9513 Counter/Timer Modes

Each Am9513 chip occupies 2 consecutive I/O addresses. The first location addresses a control port and the second a data port.

The Am9513 can be a complex chip to learn, program, and use because of its rich feature set. For detailed hardware information, consult Advanced Micro Devices' *Am9513A/Am9513 System Timing Controller Technical Manual* and your counter/timer hardware user's guide.

DriverLINX Counter/Timer Model

Figure 1 DriverLINX Counter/Timer Model

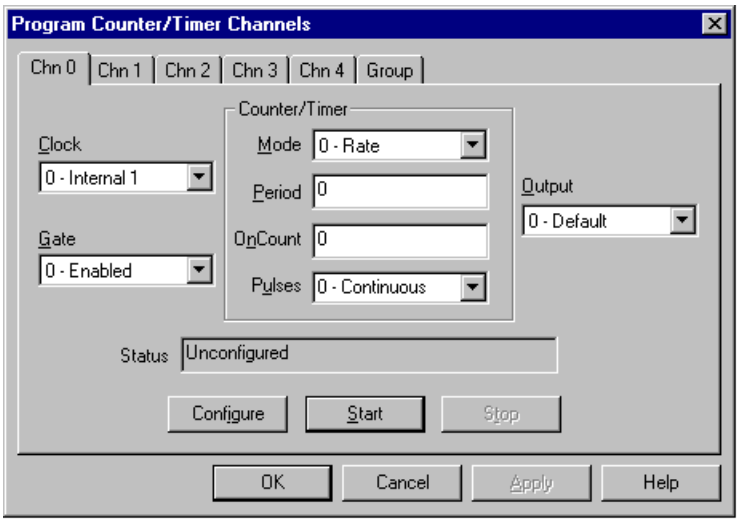
DriverLINX abstracts all counter/timer hardware chips as an array of three terminal devices. The terminals of an individual counter/timer are

- **Clock**—the source input for dividing down to a lower frequency or for counting external events.
- **Gate**—the control input for triggering, re-triggering, or gating the counter/timer operation.
- **Output**—the counter/timer output frequency, pulse, or strobe.

DriverLINX associates with each counter/timer channel four operating properties. The properties are

- **Mode**—defines the operational task for the counter/timer channel.
- **Period**—defines the cycle period or divisor for the counter/timer channel.

- **OnCount**—defines high duration of the period for asymmetrical output trains or pulses.
- **Pulses**—defines the number of periods to generate.



Capabilities of DriverLINX's counter/timer subsystem depend on the hardware features of your board.

By selecting values for these seven properties and, where necessary, making the appropriate connections between counters, applications can program DriverLINX to execute one of the counter/timer's basic operating modes or the following counter/timer operations and tasks:

- **Event counting**—16-, 32-, and 64-bit counters for signals at the **Clock** input.
- **Frequency measurement**—16- and 32-bit frequency measurement.
- **Interval measurement**—Measure time between two consecutive pulses at a single input or two pulses at separate inputs.
- **Period and pulse width measurement**—Measure duration of each cycle or half cycle.
- **Pulse generation**—Generate a variety of one-shot pulses and strobes.
- **Frequency generation**—Generate periodic pulse trains, variable duty cycle waveforms, square waves, or input-modulated waveforms.

Applications may program and operate counter/timers independently, or they may configure the operating mode for several counter/timers and start or stop them synchronously. For hardware boards that support interrupts, applications may program a list of timers whose current value DriverLINX will read into a buffer on each interrupt.

The following tables show the legal values for the **Clock**, **Gate**, **Output**, and **Mode** fields of a DriverLINX logical counter channel. Note that the capabilities of the Intel 8254 are a subset of the Am9513's capabilities.

Clocks

The **Clock** property specifies the source input for the abstract counter/timer of a Logical Channel.

Clock	Description	Intel 8254	KPCI-3140	Am9513
Internal1.. Internal5	Internal clock frequency prescaled at 1 of 5 taps	yes (Internal1 only)	yes (Internal1 only)	yes
Source1.. Source5	Use channel 1..5 source (clock) input	no	no	yes
Gate1.. Gate5	Use channel 1..5 gate input	no	no	yes
External	External clock frequency (usually positive edge)	yes	yes	yes
ExternalPE	External clock frequency (positive edge clocking)	yes	yes	yes
ExternalNE	External clock frequency (negative edge clocking)	no	yes	yes
TCNm1	Use channel N-1 terminal count output	no	yes	yes

Table 4 Allowed Values for Rate Event Clock Property

- For the Am9513-based counter/timers, you may also request that the clock input use the negative-going edge of the clock input rather than the positive edge.
- Internal1 always designates the onboard hardware clock. Internal2..Internal5 designate lower frequency taps of the master clock if the hardware supports this capability.
- If the application uses an Internal1 clock with a Period value greater than the hardware counter/timer supports, DriverLINX will automatically select available hardware prescalers to obtain the closest value to the requested Period.

Gates

The **Gate** property selects how the abstract counter/timer uses the gate input of a Logical Channel. Generally, this input gates the counting or measuring process or triggers the counter/timer operation.

Gate	Description	Intel 8254	KPCI-3140	Am9513
Enabled	Enable gate	yes	yes	yes
Disabled	Enable gate	no*	yes	yes
NoConnect	No connection	modes 0,2-4	yes	yes
LoLevel GateN	Logic low level at gate input N	no	mode 2	yes
LoEdge GateN	Negative edge at gate input N	no	modes 0,1	yes
HiLevel GateN	Logic high level at gate input N	modes 0,2-4	mode 2	yes
HiLevel GateNp1	Logic high level at gate input N+1	no	no	yes
HiLevel GateNm1	Logic high level at gate input N-1	no	no	yes
HiTcNm1	Positive edge at terminal count output N-1	no	no	yes
HiEdge GateN	Positive edge at gate input N	modes 1,5	modes 0,1	yes

Table 5Allowed Values for Rate Event Gate Property

*Some boards provide off-chip hardware that can disable the 8254's gate.

Outputs

The **Output** property programs the polarity and duty cycle of the abstract counter/timer's output port.

Output	Description	Intel 8254	KPCI-3140	Am9513
Default	Depends on operation (see "Counter Output" on page 55)	yes	yes	yes
LoToggled	Start low; toggle at TC	yes	yes	yes
LoActive	Active low pulse at TC	yes	yes	yes
LoZ	Inactive low impedance output	no	no	yes
Toggled	Toggle at TC	yes	no	yes
HiToggled	Start high; toggle at TC	yes	yes	yes
HiActive	Active high pulse at TC	no	yes	yes
HiZ	Inactive high impedance output	no	no	yes

Table 6 Allowed Values for Rate Event Output Property

DriverLINX automatically selects an output type if the application requests Default. Depending on hardware capabilities, DriverLINX chooses the output option based on the requested Mode. The Intel 8254 allows only one output mode, which depends on the operation.

Modes

The **Mode** property selects the type of rate generator or task the abstract counter/timer will perform. Mode values fall into two general groups—pulse and waveform generators and measurement tasks. Note that the generator modes (e.g., RateGen, SqWave, etc.) program a single Logical Channel of an abstract counter/timer while the measurement modes (e.g., Frequency, Interval, etc.) may program multiple Logical Channels.

Generator	Description	Intel 8254	KPCI-3140	Am9513
RateGen	Periodic rate generator	yes	yes	yes
SqWave	Square wave generator	yes	yes	yes
VDCGen	Variable duty cycle rate generator	yes	yes	yes
BurstGen	Burst rate generator	no	no	no
Divider	Frequency divider	no	yes	yes
Freq	Frequency counter	yes	yes	yes
Interval	Interval timer	yes	no	yes
Count	Event counter	yes	yes	yes
PulseWd	Pulse width measurement	yes	yes	yes
SplitClk	Split frequency rate generator	no	no	no

Generator	Description	Intel 8254	KPCI-3140	Am9513
FskGen	Frequency-shift keying	no	no	yes
PulseGen	Pulse generator	no	yes	yes
Retrig RateGen	Retriggerable rate generator	no	no	yes
Retrig SqWave	Retriggerable square wave generator	no	no	yes
Count32	32-bit event counter	no	yes	yes
Count64	64-bit event counter	no	yes	yes
Freq32	32-bit frequency counter	no	yes	yes
FreqRatio	Frequency ratio counter	no	no	no
OneShot	One-shot pulse or strobe	yes	yes	yes
Retrig OneShot	Retriggerable one-shot pulse or strobe	yes	no	yes

Table 7 Allowed Values for Rate Event Mode Property

- Some of the above mode field options, e.g., BurstGen, specify features that require external connections, which some vendors have prewired into their products.
- Other options, such as frequency measurement modes, require external user connections between counter/timer terminals.

DriverLINX Task Model

To manage a user application's data-acquisition requests, DriverLINX creates tasks. A DriverLINX task consists of the set of hardware and system resources and the board-specific protocols required to execute the data-acquisition request. Applications can start tasks, monitor tasks, and stop tasks by submitting Service Requests to DriverLINX.

Hardware Sharing

DriverLINX allows multiple applications to share a data-acquisition device or allows multiple tasks to run on a device if the hardware can support concurrent operations. To support hardware sharing and concurrency, DriverLINX assigns resources to each task and then compares the resource requirements of a new task with the in-use resources of all current tasks. If the new requirements do not conflict with the current in-use resources, DriverLINX updates the in-use resources and starts the task. Otherwise, DriverLINX rejects the newly requested task.

Creating Tasks

User applications create data-acquisition tasks by setting the properties of a Service Request to values that specify the task. Then the application submits the Service Request to DriverLINX, which transforms each Service Request into a procedure for performing the task on the requested hardware subsystem. To execute a new task, DriverLINX performs the following steps for each Service Request:

1. Audit the Service Request fields to determine if the hardware can perform the task.
2. Request necessary hardware and system resources to perform task.
3. Convert the Service Request into the hardware parameters and protocols to perform the task.
4. Execute the task on the hardware.
5. Notify application of any requested task events as they occur.
6. Wait for the task to complete.
7. Release requested hardware and system resource used by the task.

If DriverLINX detects any errors in the Service Request or in the hardware during the task, it aborts the task and returns an error code to the application. If the application requests hardware resources that are already in use by another thread or process, DriverLINX also stops the task and notifies the application.

Monitoring and Stopping Tasks

A Start operation fills in the taskId property. DriverLINX uses the taskId to determine to which task a Status or Stop operation applies.

Applications may also check the status of a task or terminate a task by modifying the operation property of the Service Request used to create the task and resubmitting it to DriverLINX. To check status, change the operation property to “status”. To terminate a task, change the operation property to “stop”.

DriverLINX Events

Applications can request that DriverLINX notify the *application* of significant events during execution of a task. By designing a data-acquisition task to use events, an application can overlap data processing with data collection. Events allow the application to coordinate these two activities without the overhead associated with polling for the status of the data collection task and without the scheduling problem of coordinating data processing with partial data collection.

DriverLINX posts events to an application through the Windows messaging mechanism. DriverLINX supports the following messages:

Message	Description	Posted
ServiceStart	Task is starting	Default. Can disable.
ServiceDone	Task is complete	Default. Can disable.
BufferFilled	Buffer processing complete	Can enable.
DataLost	Data over/underrun	Always reported.
TimerTic	Timer interrupt occurred	Non-buffered CT task.
StartEvent	Start event detected	Can enable.
StopEvent	Stop event detected	Can enable.
CriticalError	Hardware error	Always reported.

Table 8 DriverLINX Messages

The most useful events for applications are *ServiceDone*, *BufferFilled*, and *DataLost*.

- The *ServiceDone* event notifies the application that DriverLINX terminated the task. Tasks may end because the application stopped it, the stop event condition in a Service Request was satisfied, or DriverLINX detected a run-time error and stopped the task.
- The *BufferFilled* event notifies the application that DriverLINX has read or written the current buffer. Applications can use this message with multiple data buffers to eliminate polling the driver for the status of the task and to overlap data processing with data acquisition.
- The *DataLost* event notifies the application that DriverLINX detected that the hardware was filling or emptying buffers faster than the application or driver could process the buffers.

The other DriverLINX events are useful for special cases.

- The *ServiceStart* event notifies the application that DriverLINX is starting the task. An application might use this event to provide visual feedback to the user interface that the task is starting.
- The *TimerTic* event notifies the application that DriverLINX has processed a clock interrupt. DriverLINX only reports this event for the counter/timer subsystem when the task is not using data buffers.
- The *StartEvent* notifies the application that DriverLINX detected that the logical condition the application specified in the Service Request's Start Event is true. DriverLINX can only report this event if the hardware generates an interrupt associated with the Start Event.
- The *StopEvent* notifies the application that DriverLINX detected that the logical condition the application specified in the Service Request's Stop Event is true. DriverLINX can only report this event if the hardware generates an interrupt associated with the Stop Event.
- The *CriticalError* event notifies the application that DriverLINX detected an unexpected critical error other than *DataLost*. This usually indicates either the hardware or software is malfunctioning and needs repair or re-configuration.

DriverLINX Operations

For most counter/timer hardware, applications can select one of five operations for a task. The basic counter/timer task operations are

- ***Initialize***—resets the counter/timer subsystem software and/or hardware.
- ***Configure***—set up a counter/timer for a task, but do not start the task.
- ***Start***—set up and arm a counter/timer for a task. The **Gate**, **Clock**, and **Mode** properties determine when the hardware starts counting.
- ***Status***—return the current counter/timer count value and status to the application.
- ***Stop***—disarm the counter/timer task and make the task resources available for new tasks.

The *Initialize*, *Configure*, and *Start* operations all create a DriverLINX task. The task that DriverLINX creates for the first two operations exists only briefly during the

application's function call to DriverLINX. For a *Start* operation, however, DriverLINX creates a task that may exist indefinitely until the application explicitly ends the task with a *Stop* operation or DriverLINX ends the task because the Stop Event has become true.

DriverLINX Modes

For most counter/timer hardware, DriverLINX supports three task modes, *OTHER*, *POLLED* and *INTERRUPT*.

- When an application uses *OTHER* mode, DriverLINX initializes the subsystem or configures a Logical Channel without starting the counter.
- When an application uses *POLLED* mode, DriverLINX starts the counter/timer hardware running, but it does not automatically report any status information about the task to the application.
- When an application uses *INTERRUPT* mode, DriverLINX starts the counter/timer hardware running with a hardware interrupt enabled. At each interrupt, DriverLINX either sends a *TimerTic* event to the application or saves the current count of the requested counter/timers into a data buffer.

For other subsystems, polled mode tasks start and stop before DriverLINX returns control to the application.

When using polled mode counter/timer operations, DriverLINX returns control to the application after starting the counter/timer hardware. Applications must use the *Status* operation to read the current count value of a counter/timer. The counter/timer task will run until the application ends it with a *Stop* operation.

When using interrupt mode counter/timer operations, DriverLINX also returns control to the application after starting the counter/timer hardware. However, if the application specified data buffers in the Service Request, DriverLINX will automatically read and store the current counter value(s) into the buffer. The application may request that DriverLINX read the next Logical Channel in the Channel list at each interrupt or that DriverLINX read all Logical Channels at each interrupt. If the application is not using buffers, then DriverLINX sends a TimerTic event to the application at each interrupt.

Individual and Group Tasks

Applications can control individual counter/timer channels as separate tasks or they can synchronize the starting and stopping of multiple channels. To collect multiple channels into a group, the application first performs *Configure* operations on each channel in the group to set up the hardware. Then the application can start the channels in the group by executing a Service Request with a *Start* operation that lists the group's channels in the Service Request's channel list. By using a *Stop* operation instead, the application can simultaneously stop all channels in the group. For more information, see "Group Tasks" on page 38.

Mapping Logical Channels to Counter/Timer Hardware Channels

DriverLINX maps the hardware's counter/timer channels to consecutive Logical Channels. The following table shows the correspondence between the hardware channels and Logical Channels. Note that DriverLINX always uses zero-based

numbering for Logical Channels while vendors often use one-based channel numbering.

Logical Channel	0	1	2	3	4	5	6	7	8	9
CTM-05	1	2	3	4	5					
CTM-05A	1	2	3	4	5					
CTM-10	1A	2A	3A	4A	5A	1B	2B	3B	4B	5B

Table 9 Map of Logical Channels to Counter/Timer Hardware Channels

For other models, see the appropriate *Using DriverLINX with your Hardware* manual.

Digital I/O Hardware

Software cannot read or control the strobe lines for digital inputs without external connections.

The MetraByte counter/timer boards support one or more digital I/O ports. The CTM-05/A board has one 8-bit digital input port with latch and one 8-bit digital output port with latch. The CTM-10 board has two 8-bit digital input ports with latches and two 8-bit digital output ports with latches. A strobe line input at each input port controls whether the input data passes through the latch or is held by the latch. There is no software control over this strobe line. For more information, see the *CTM-10 and CTM-05/A User's Guide*.

These digital ports are physically independent of the counter/timers and do not have any internal connections to the counter/timers. Also, the digital I/O ports do not generate any hardware interrupts. Applications can read or write the digital ports independently of the counter/timers. DriverLINX does support reading a digital input port at each counter/timer interrupt to start or stop a counter/timer task.

The CTM Series boards also have a digital input line that generates a hardware interrupt. DriverLINX models this line as a special-purpose, 1-bit digital input channel. Associated with the interrupt input line is another external input line that enables or disables the interrupt input line. DriverLINX has no direct hardware control over this gating line.

For other models, see the appropriate *Using DriverLINX with your Hardware* manual for details on digital I/O features.

Mapping Logical Channels to Digital Hardware Channels

DriverLINX maps the hardware's digital channels to consecutive Logical Channels. The following table shows the correspondence between the hardware channels and Logical Channels. Note that DriverLINX always uses zero-based numbering for Logical Channels while vendors often use one-based channel numbering.

Logical Channel	0	1	2
CTM-05	Port A I/O	external interrupt	
CTM-05A	Port A I/O	external interrupt	
CTM-10	Port A I/O	Port B I/O	external interrupt

Table 10 Map of Logical Channels to Digital Hardware Channels

To support writing hardware-independent applications, DriverLINX assigns special fixed Logical Channel numbers as aliases for the Logical Channel of an external interrupt line.

For other models, see the appropriate *Using DriverLINX with your Hardware* manual for details on digital I/O features.

Properties of Logical Channels

The hardware design of the digital channels on the CTM Series does not support reading back the last value written to a digital output port. Writing Logical Channel 0 outputs data to a physically different latch than when an application reads Logical Channel 0. If needed, applications must maintain their own shadow copies of the values written to a digital output port.

Applications that want to share an output port with another thread or process can do so without knowing the current output value of the port. Use either bit-level I/O (see "Reading or Writing Specific Digital Bits" on page 72) or extended Logical Channel addressing (see "Combining or Splitting Logical Channels" on page 31).

Combining or Splitting Logical Channels

DriverLINX also supports bit-level I/O using masks. See "Reading or Writing Specific Digital Bits" on page 72.

DriverLINX supports a software extension to Logical Channel addressing that allows applications to combine adjacent Logical Channels into a single channel or split a Logical Channel into smaller addressable parts. For instance, applications can address individual bits on the digital I/O board or read and write multiple channels with a single operation.

To use the Logical Channel addressing extensions, form a 16-bit Logical Channel address by combining the channel number of an addressable unit with a size field as follows:

	Always 0	Size	Channel
Bits	15	14..12	11..0
Range	0..1	0..7	0..4095

Table 11 Field Layout of an Extended Logical Channel Address

The following table specifies the 3-bit size codes:

Size Code	Unit	Bits
0	native	varies with hardware
1	bit	1
2	half nibble	2
3	nibble	4
4	byte	8
5*	word	16
6*	dword	32
7*	qword	64

Table 12 Size Codes for Extended Logical Channel Address

* Neither the CTM-05/A nor CTM-10 support 32- or 64-bit digital I/O, and the CTM-05/A does not support 16-bit digital I/O.

“Native” units refer to the hardware-defined digital channel size. For most boards, this is the same as an 8-bit byte. When using extended Logical Channel addressing, DriverLINX groups digital bits in units defined by the size code and then assigns consecutive channel numbers starting from zero. For instance, a CTM-10 with two 8-bit ports would have the following channel addresses for each size code:

Unit	Channels	Address (dec)	Address (hex)
native	0..1	0..1	0..1
bit	0..15	4096..4111	1000..100F
half nibble	0..3	8192..8195	2000..2003
nibble	0..2	12288..12290	3000..3002
byte	0..1	16384..16385	4000..4001
word	0	20480	5000

Implementation Notes

- For extended Logical Channel addressing of unit sizes less than the native size, DriverLINX only supports single-value transfers.
- For block I/O transfers, DriverLINX only allows Logical Channel addressing at unit sizes equal or larger than the native size. Note that extended Logical Channels may not map to consecutive physical channels. Because DriverLINX uses the CPU's block I/O instructions for polled, block I/O transfers, some bytes will not represent I/O ports.
- When using size codes larger than the native addressing unit, you may not be able to address all hardware ports if the number of available digital I/O lines is not an integral multiple of the size unit.

Programming Counter/Timers with DriverLINX

DriverLINX Counter/Timer Operations

The DriverLINX API is available as a C/C++, VBX, or ActiveX interface. See "Interfacing to DriverLINX" on page 43.

This chapter describes how to control your counter/timer board using the DriverLINX API for the most common tasks. Each section presents background information and concepts for performing a particular task and then presents DriverLINX procedures in C/C++ and Visual Basic for a task. Users of other programming languages should use the ActiveX control interface for DriverLINX and look at the Visual Basic examples for how to program tasks.

The DriverLINX counter/timer model provides over 12,000 potential configurations for each counter/timer channel. If you allow for interconnecting counter/timer channels, the number of potential combinations is staggering. Naturally, real hardware only supports a subset of possible configurations. To keep things manageable, follow these simple steps:

1. Decide the basic task category you need—event counting, frequency measurement, interval measurement, period and pulse width measurement, pulse and strobe generation, frequency generation.
2. Go to the section of this guide that describes using a counter/timer for your task.
3. Decide if you need a repetitive or non-repetitive measurement or waveform generation.
4. Decide if you need triggering (rising or falling edge) or gating (active high or low levels).
5. Look at the Rate Event Properties tables for your task to determine if DriverLINX supports your requirements.
6. Look at "Counter Output" on page 55 to set up the counter/timer output.

If the Rate Event Properties tables do not show an entry for your requirements, then you may need additional external hardware and/or multiple counter/timer channels to support your task. Look at "Hardware Reference" on page 113 Operating Modes to see if any of the basic hardware modes, alone or in combination, will meet your requirements. If so, look for the corresponding mode in one of the Rate Event Properties tables and configure each counter/timer channel as shown. If you do not

find what you are seeking, then you will need to design some external hardware for your application.

DriverLINX Tasks for All Subsystems

The following DriverLINX tasks are common for all subsystems and all supported hardware boards:

- **Connecting to a driver**—DriverLINX requires applications to open, select, and close drivers for specific boards. See "Opening and Closing a DriverLINX Device Driver" on page 44.
- **Selecting a driver**—DriverLINX allows your application to control multiple different types of hardware boards. See "Selecting a DriverLINX Device Driver" on page 46.
- **Edit a Service Request**—DriverLINX allows your application to display the *Edit Service Request* property page to quickly test or modify Service Requests during application development. See "Displaying the Edit Service Request Dialog" on page 47.
- **Error reporting**—Applications can use DriverLINX to display DriverLINX errors in message boxes. See "Reporting a DriverLINX Error" on page 48.
- **Stopping a task**—Applications can use a Service Request to stop a DriverLINX task. See "Stopping A DriverLINX Task" on page 49.
- **Device initialization**—DriverLINX requires your application to initialize all subsystems on a board before performing any other tasks. See "Initializing the Device" on page 50.
- **Subsystem initialization**—Applications can initialize a single, specified subsystem. See "Initializing a Counter/Timer Subsystem" on page 51.
- **Using DriverLINX messages and events**—DriverLINX reports task information to your application using the Windows messages or events. See "Using Messages and Events" on page 52.

DriverLINX Tasks for Counter/Timer Subsystem

The following DriverLINX tasks are specific to the counter/timer subsystem:

- **Counter output**—DriverLINX defines default output signals for counter/timer channels as well as application-defined outputs. See "Counter Output" on page 55.
- **Status polling**—Applications can use a Service Request to monitor the current value and status of a counter/timer. See "Status Polling a Counter/Timer" on page 56.
- **Configuring a counter/timer**—Applications can configure and arm a counter/timer without actually starting the counter. See "Configuring a Counter/Timer Channel" on page 57.
- **Converting between counts and time**—DriverLINX supports methods to convert between counter tics and time. See "Converting Between Counts and Time" on page 58.

The following task-oriented functions, although specific to the counter/timer subsystem, are defined to be portable across data-acquisition boards:

- **Event counting**—DriverLINX supports counting external events using 16-, 32-, or 64-bit counters. See “Using Task-Oriented Functions” on page 79.
- **Frequency measurement**—DriverLINX supports counting events for a known time period. See “Frequency Measurement” on page 85.
- **Interval measurement**—DriverLINX can measure the interval between two pulses on a single input line or on two separate input lines. See “Interval Measurement” on page 92.
- **Period and pulse width measurement**—DriverLINX can measure the duration or period of a single cycle of an input or the duration of the positive or negative half cycle of an input. See “Period and Pulse Width Measurement” on page 96.
- **Pulse and strobe generation**—DriverLINX can generate a variety of single, delayed pulses and strobes. See “Pulse and Strobe Generation” on page 101.
- **Frequency generation**—DriverLINX can generate a variety of pulse trains, variable duty cycle waveforms, square waves, and frequency-shift keyed waveforms. See “Frequency Generation” on page 107.

Foreground Tasks

The simplest technique for your application to control counter/timers with DriverLINX is to use a foreground task. Your application starts a counter/timer using a DriverLINX Service Request with the Mode property set to “Polled” and the Operation property set to “Start”. DriverLINX will configure, arm, and start a counter/timer task.

If your application needs to monitor the current count of the counter/timer, it should poll the counter/timer’s status. See “Status Polling a Counter/Timer” on page 56. DriverLINX will return to your application the current count value with each Service Request. See “Converting Between Counts and Time” on page 58 for how to convert a count to seconds.

When your application wants to end the current task or reprogram the counter/timer with a new task, it must first stop the current task. See “Stopping A DriverLINX Task” on page 49.

If your application needs to first configure several counter/timer channels and then start them simultaneously, see “Group Tasks” on page 38.

Background Tasks

DriverLINX can also run counter/timer tasks in the background asynchronously collecting data while the application processes other data in the foreground. DriverLINX can support asynchronous mode only if

- the counter/timer board supports interrupts, and
- you have configured the board to use an available interrupt.

Background, interrupt-driven tasks can either report an event to the application at each interrupt or they can use a data buffer to collect samples at each interrupt.

- **Unbuffered background counting**—DriverLINX posts a "timer tic" event to the application at each interrupt. See "Using a Counter/Timer to Generate Clock Messages" on page 60.
- **Buffered background counting**—DriverLINX stores the current counter value into a memory buffer at each interrupt. See "Storing the Counter/Timer Value at Each Interrupt" on page 61.

Group Tasks

The preceding tasks allow you to program an independent task on each counter/timer channel. You can also configure multiple counter/timer channels and then simultaneously start or stop them as a group.

- **Configuring channels for a group**—DriverLINX allows the application to configure, but not start, a Logical Channel so that the application can later start several channels simultaneously. See "Controlling Group Tasks" on page 63.
- **Polled mode groups**—DriverLINX can start or stop a non-interrupt task that controls multiple counter/timer channels. The application can read the individual counter values by status polling. See "Polled Mode Groups" on page 65.
- **Interrupt mode groups**—DriverLINX can start or stop an interrupt-driven task that controls multiple counter/timer channels. If the application specifies data buffers, DriverLINX reads the counter values into the buffer at each interrupt. Otherwise, DriverLINX reports a "timer tic" event to the application at each interrupt. See "Interrupt Mode Groups" on page 67.

These examples illustrate the most common counter/timer tasks that most applications need. You can also create special-purpose counter/timer services by programming individual counter/timers with any of the hardware-supported modes. See "Hardware Reference" on page 113 Operating Modes for more information.

DriverLINX Tasks for Digital Subsystems

For the CTM Series, DriverLINX also supports the following digital I/O operations:

- **Single value I/O**—DriverLINX synchronously reads or writes a single value to an I/O port. See "Reading or Writing a Single Digital Value" on page 68.
- **Masked, single value I/O**—DriverLINX synchronously reads or writes only the selected bits of an I/O port. See "Reading or Writing Specific Digital Bits" on page 72.
- **Block transfer on an I/O port**—DriverLINX synchronously transfers a block of data to or from an I/O port. See "Rapidly Transferring a Block of Digital Data" on page 75.

Using DriverLINX's Service Requests

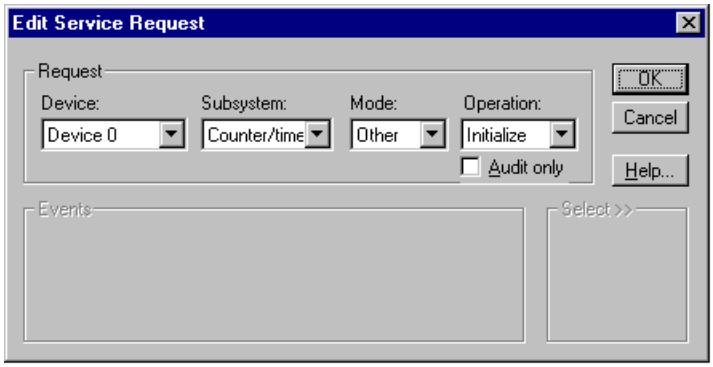
All counter/timer operations use the Service Request to pass your task specification to DriverLINX. If you are using C/C++, the Service Request is a data structure defined in the include file, "**drvlinx.h**". If you are using the ActiveX (OCX) control to program DriverLINX, the Service Request is an instance of the control object with member properties that you set up.

The Edit Service Request property page is a visual representation of the Service Request object that your application programs.

Whatever language you are using, the principles of setting up a Service Request are the same, although the syntax varies slightly with each language. This manual will use the Service Request terminology displayed in the *Edit Service Request* property page. See the example programs or the on-line *DriverLINX Technical Reference Manual* for the language-specific syntax. See "Displaying the Edit Service Request Dialog" on page 47 for how to pop-up the *Edit Service Request* dialog in your applications.

Properties Common to All Service Requests

All Service Requests require that the application define the following properties in the Request Group:



- **Device**—specifies the Logical Device number of a configured device as the target of this Service Request.
- **Subsystem**—specifies the primary Logical Subsystem that is the target of this Service Request.
- **Mode**—suggests the hardware technique (Other, Polled, Interrupt, DMA) that DriverLINX should use for this Service Request. DriverLINX may select another mode to execute the task.
- **Operation**—specifies the primary command to execute for this Service Request.

The additional Service Request groups and properties depend on the selected subsystem, operation, and task your application intends to perform. See "DriverLINX Counter/Timer Operations" on page 35.

Modes and Operations for Counter/Timers

DriverLINX's counter/timers use only the following modes:

- **Other**—used to initialize the counter/timer subsystem or configure a Logical Channel without starting counting.
- **Polled**—specifies that applications issue software commands to DriverLINX to start, monitor, and stop counters.
- **Interrupt**—specifies that DriverLINX performs counting operations at each external interrupt.

For each **Mode** using the counter/timer subsystem, DriverLINX supports the following operations:

Mode	Operation	Description
Other	Initialize	Initialize counter/timer subsystem
	Configure	Initialize a Logical Channel without starting counting
Polled	Start	Set up and start a counter/timer task
	Status	Return status and current value of a counter/timer
	Stop	Stop a counter/timer task
Interrupt	Start	Set up and start a background counter/timer task
	Status	Return status and position of next buffer sample to process
	Stop	Stop a background counter/timer task

Table 13 Allowed DriverLINX Counter/Timer Operations by Mode

Other Mode

DriverLINX executes *Other Mode* tasks synchronously, i.e., the task starts, executes, and finishes before DriverLINX returns control back to the calling application.

Polled Mode

For subsystems other than the counter/timer, DriverLINX executes Polled Mode *tasks synchronously.*

For the counter/timer subsystem, DriverLINX uses a quasi-synchronous technique. For *Start* operations, DriverLINX initializes and starts the task before returning control to the application. Applications then call DriverLINX to monitor the status of the task or to stop the task. DriverLINX does not automatically stop polled tasks unless DriverLINX detects an error while executing an application-issued command.

Interrupt Mode

DriverLINX executes *Interrupt Mode* tasks asynchronously, i.e., DriverLINX initializes the task and then returns control to the application. At each interrupt, DriverLINX briefly regains control from the application and either starts the task, collects task data, reports status to the application, or stops the task.

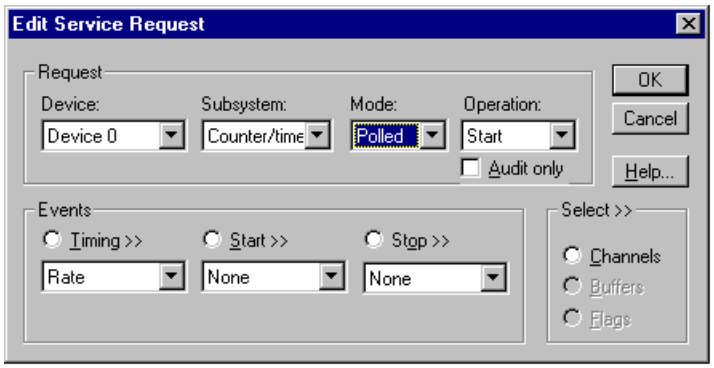
The application specifies the work DriverLINX performs at each interrupt by the properties in the Service Request. DriverLINX reports task status to the application

using either the Windows messaging system or control events. See “DriverLINX Events” on page 27.

Using Events to Control Service Requests

A few Service Request operations do not use events.

DriverLINX uses the concept of an “event” to logically control the processing of a Service Request task. For all tasks, DriverLINX requires your application to specify an event for the three events in the Events Group.



- **Timing**—specifies the timing, or pacing, clock DriverLINX uses during processing a Service Request task.
- **Start**—specifies when DriverLINX starts counting or acquiring data for this Service Request task.
- **Stop**—specifies when DriverLINX stops counting or acquiring data for this Service Request task.

The example Service Request above defines a synchronous (polled) start of a counter/timer channel. The application specifies the Logical Channel and configuration for the counter/timer channel in the Rate Event properties (not shown in the above dialog).

The on-line *DriverLINX Technical Reference Manual* defines an extensive set of possible events for a wide variety of hardware and data-acquisition protocols. A DriverLINX driver for counter/timers, however, uses only a few events that this guide describes.

See the on-line DriverLINX Technical Reference Manual for more information about the Logical Device Descriptor.

DriverLINX defines events as hardware and vendor independent and allows applications to use each event as a timing, start, or stop event whenever logical. Some hardware boards, however, do not support events that are common to the majority of similar products, or they support only a subset of the event’s parameters. To allow applications to handle hardware-dependent features, DriverLINX publishes board-specific information in the Logical Device Descriptor. Applications that need hardware independence should query the Logical Device Descriptor to determine the available features of a board.

Events for the Counter/Timer

DriverLINX’s counter/timer operations use only the following events:

- **None**—indicates that the task does not require this event.
- **Command**—indicates that the Service Request starts or stops on software command.

- **Terminal Count**—indicates that the Service Request completes when the hardware has transferred all samples into or out of the data buffers.
- **Digital**—when used as a start or stop event, specifies a digital input channel to read and a masked set of bits to compare to a pattern. See "Using Digital Start and Stop Events" on page 63. When used as a timing event, specifies the external interrupt input line on the hardware, which DriverLINX uses as a "clock" to pace the Service Request task. See "Using the External Interrupt Input Line" on page 62.
- **Rate**—specifies the operating parameters for a Logical Channel of the counter/timer subsystem.

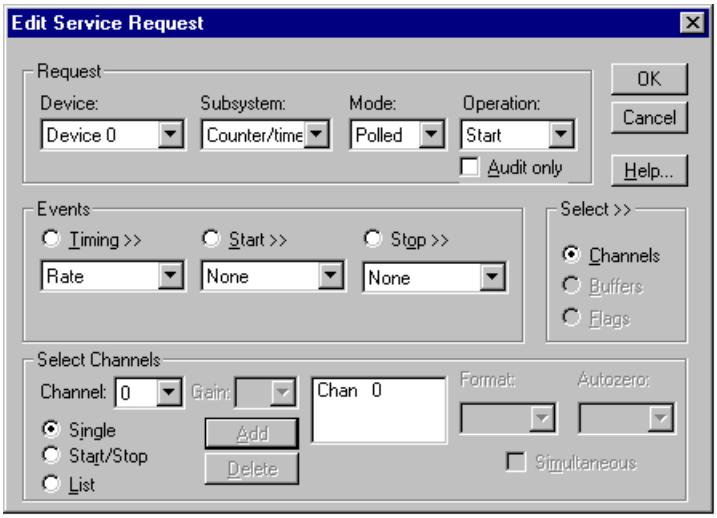
The following table defines the events DriverLINX supports for each Mode on the counter/timer subsystem.

Mode	Timing	Start	Stop
Other	Rate	None	None
Polled	None Rate	None Command	None Command
Interrupt	Rate Digital	None Command Digital	None Command Digital Terminal Count

Table 14 Allowed DriverLINX Counter/Timer Events by Mode

Specifying Counter/Timer Channels in a Service Request

For most counter/timer Service Request operations, you specify the Logical Channel for the operation in the *Channel* property of a Rate Event. For group operations on multiple Logical Channels, you specify the members of the group using the *Select Channels* properties of a Service Request. Depending on the task and operation, your application can specify a single Logical Channel, a consecutive range of Logical Channels (Start/Stop), or a random list of Logical Channels.



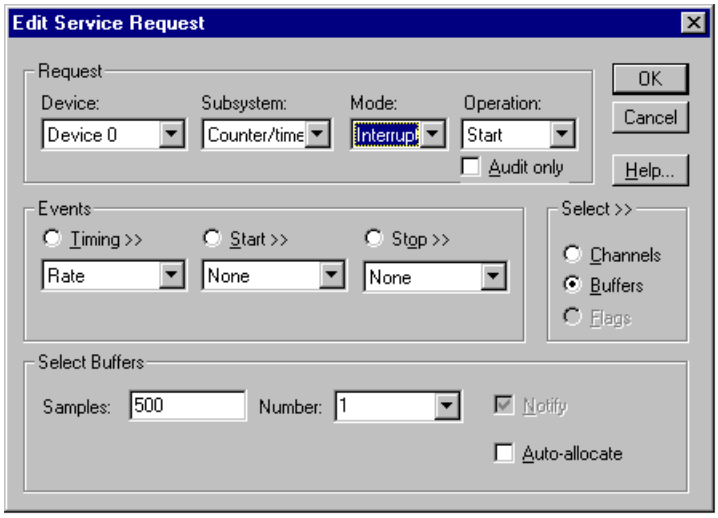
In a preemptive multitasking system, the delay between each instruction can vary significantly and unpredictably.

For channels in a group, DriverLINX uses a single hardware operation to start or stop members of the group. Note, however, that your application can specify Logical Channels in a group that map to two different hardware chips on the CTM-10. In this case, DriverLINX must use two separate instructions to control each chip.

Specifying Data Buffers in a Service Request

DriverLINX can transfer multiple samples in one Service Request by using data buffers.

- For group counter/timer requests that do not use interrupts, applications can specify one buffer with a length equal to the number of Logical Channels in the group. See “Polled Mode Groups” on page 65.
- For group counter/timer requests using external interrupts, applications can specify multiple Logical Channels and up to 255 fixed-length buffers of arbitrary size. See “Interrupt Mode Groups” on page 67.
- For untimed digital I/O transfers DriverLINX will use fast CPU block I/O instructions. Applications can specify one Logical Channel and one buffer as long as 128 KB. See “Rapidly Transferring a Block of Digital Data” on page 75.



To transfer only a single value in a Service Request, see “Reading or Writing a Single Digital Value” on page 68.

Interfacing to DriverLINX

To use DriverLINX, applications must incorporate the DriverLINX API into their code. Applications can then control multiple DriverLINX drivers and multiple Logical Devices using DriverLINX’s API.

The DriverLINX API supports multiple languages for Win32 application development. Currently DriverLINX supports two different language interfaces. The header files to support these languages are all in the **DLAPI** subdirectory where you installed DriverLINX.

- **C/C++**—a data structure and function call API available for 32-bit C/C++ applications.
- **ActiveX**—or OLE 2.0 Custom Control (OCX) in a 32-bit interface. Visual Basic 4.0, Microsoft Visual C++ 4.0, Delphi 2.0, and most new language tools support 32-bit ActiveX controls.

A hardware-specific DriverLINX driver may not be available on all platforms.

All DriverLINX language interfaces bind to "**DrvLNX32.DLL**". This DLL is operating system independent and allows you to run your binary application on either Windows 95/98/Me, or Windows NT/2000 as long as you have installed the correct DriverLINX driver for your hardware and operating system.

Interface with C/C++

To use the C/C++ interface,

1. Add the following C header files in the **DLAPI** subdirectory to your program *after* including the standard Windows definitions:

```
#include "drvlinx.h"   /* DriverLINX API */
#include "dlcodes.h"   /* DriverLINX error codes and macros */
#include "oemcodes.h"  /* OEM-specific model codes */
```

2. Add the following import library to your project or linker's list of libraries,

- **DRVLNX32.LIB**

Using Non-Microsoft C/C++ Compilers

Note that some compiler tools, such as Borland C/C++, use a library file format that is not compatible with Microsoft's format. Please check the **DLAPI** subdirectory where you installed DriverLINX for library files compatible with your compiler. If present, you will have to rename them to the above library names. If not present, most compilers provide a tool to create a linking library given a DLL. Please consult your compiler vendor's documentation for assistance.

Interface with the Custom Control

DriverLINX supports one type of custom control:

1. **OCX**—32-bit ActiveX (formerly OLE) custom control

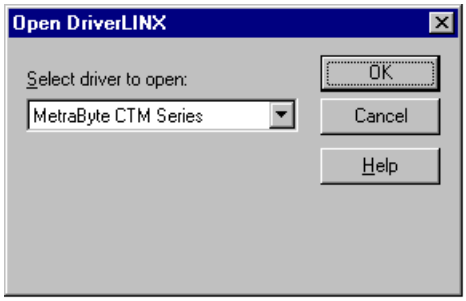
ActiveX Control

To add the ActiveX Custom Control (OCX) to your project, see the instructions for your compiler and check the subdirectories where you installed DriverLINX for any additional documentation. The filename of the 32-bit control is **DLXOCX32.OCX.** The controls it contains are in a library called `DriverLINX ActiveX Controls`.

Opening and Closing a DriverLINX Device Driver

To communicate with a physical device, applications must first open a device driver. With DriverLINX, applications can either specify the name of a specific driver or they can supply a blank name. In this case, or if the app specifies an unknown name, DriverLINX will display the *Open DriverLINX* dialog requesting the user to select a driver to open.

For the MetraByte CTM Series, the name of the driver is “KMBCTM” and the driver description is “MetraByte CTM Series”.



Applications should close the device driver when they no longer need its services. Closing a DriverLINX driver stops all active tasks and unloads the driver from memory.

Open a Driver in C/C++

To load and prepare a DriverLINX driver for application use, call the following function:

```
HINSTANCE DLLAPI OpenDriverLINX (const HWND hWnd, LPCSTR name);
```

Parameter	Type/Description
hWnd	**HWND** Specifies one of the caller’s Window handles.
Name	**LPCSTR** Specifies the name of the DriverLINX driver to load. If NULL or the string specifies an unknown driver, DriverLINX displays the Open DriverLINX dialog box.

This function returns an “instance handle” that the application must use to identify the DriverLINX driver for the **SelectDriverLINX** and **CloseDriverLINX** function calls. See “Selecting a DriverLINX Device Driver” on page 46 and “Close a Driver in C/C++” on page 45.

Open a Driver with the Custom Control

To load and prepare a DriverLINX driver for application use with either the VBX or OCX control, simply set the *Req_DLL_name* property to the name of the desired driver.

Close a Driver in C/C++

To stop all active tasks and unload a DriverLINX driver, call the following function:

```
VOID DLLAPI CloseDriverLINX (const HINSTANCE hDLL);
```

Parameter	Type/Description
hDLL	**HINSTANCE** Specifies the instance handle returned by an OpenDriverLINX call.

Close a Driver with the Custom Control

To stop all active tasks and unload a DriverLINX driver, simply set the *Req_DLL_name* property to a null string.

Selecting a DriverLINX Device Driver

To specify which hardware to control, DriverLINX uses an addressing scheme that consists of the following parts:

- Logical Driver—the DriverLINX software for one or more devices in a manufacturer's product family.
- Logical Device—the number you assigned to a particular physical device during configuration.
- Logical Subsystem—the board's hardware components the application intends to use.
- Logical Channel(s)—the data channels of a subsystem that the application intends to use.

Applications specify the Logical Device, Subsystem, and Channel in the Service Request. DriverLINX uses the last driver the application opened or selected for the Logical Driver address.

If your application is controlling multiple devices that use different DriverLINX device drivers, then the application must select the correct DriverLINX Logical Driver before sending it a Service Request or other command.

Selecting a Driver in C/C++

To select a DriverLINX Logical Driver, call the following function before calling any other DriverLINX function:

```
HINSTANCE DLLAPI SelectDriverLINX (const HINSTANCE hDLL);
```

Parameter	Type/Description
hDLL	**HINSTANCE** Specifies the instance handle returned by an OpenDriverLINX call.

This function returns the "instance handle" of the last selected driver, if SelectDriverLINX succeeds. If DriverLINX detects an error, SelectDriverLINX returns zero.

Selecting a Driver with the Custom Control

The application should create at least one separate instance of the control for each DriverLINX driver the application opens. See "Open a Driver with the Custom Control" on page 45 for how to open a DriverLINX driver. The control instance will automatically select the correct DriverLINX driver before sending any commands to DriverLINX.

Displaying the Edit Service Request Dialog

Applications can easily display the *Edit Service Request* property page at run time. Most often you will find this a handy tool while you are developing and testing your application, but you can also use it as a "hidden" feature for supporting problems with a shipping product. Use this feature to

- experiment with different hardware capabilities,
- visually inspect how your application set up a Service Request,
- modify an incorrect property during testing without recompiling your program,
- quickly learn how your application responds to different data-acquisition rates or conditions,
- act as a temporary user interface before developing your own interface.

To pop-up the *Edit Service Request* dialog, first initialize the Service Request for any task of your choosing. Then set the **EDIT** flag. When your application calls DriverLINX, it will display the dialog. When the user dismisses the property page, DriverLINX will remove the **EDIT** flag and return a result code. If DriverLINX returns no error, simply recall DriverLINX with the current Service Request to have DriverLINX execute it. If DriverLINX returns an error, the user canceled the *Edit Service Request* property page. Your application should probably not execute the Service Request.

Display Edit Service Request Dialog Using C/C++

```
//***********************************************
// Use this procedure to show Edit Service Request
//***********************************************

UINT ShowEditSR (LPServiceRequest pSR)
{
  // Caller sets up Service Request
  pSR->operation = (Ops)(pSR->operation | EDIT);
  // DriverLINX automatically removes EDIT flag
  // Caller can execute SR if there are no errors
  return DriverLINX(pSR);
}
```

Display Edit Service Request Dialog Using Visual Basic

```
' Use this procedure to show Edit Service Request

Function ShowEditSR (dl As DriverLINXSR) As Integer
  ' Caller should set up Service Request
  dl.Req_op_edit = DL_True
  dl.Refresh

  ' DriverLINX automatically removes Req_op_edit flag
  ' Caller can execute SR if there are no errors

  ShowEditSR = dl.Res_result
End Function
```

Reporting a DriverLINX Error

Applications can use DriverLINX to display a pop-up message box to the user describing the error or result of the last DriverLINX Service Request. Simply replace the value of the *Operation* property in the Service Request with the "MessageBox" operation and resubmit the Service Request to DriverLINX.

The DriverLINX message box displays the error severity, subsystem, and error text. Error severities are

- **Warning**—errors that do not result in failure of function, such as data overruns.
- **Abort**—Requested function was not performed. No ongoing functions were disturbed. Request may be repeated after correcting the error.
- **Fatal**—Request was terminated with an unrecoverable error and/or data loss.
- **Internal**—Unexpected errors resulting from corruption of device driver data or device driver programming errors.

See the on-line *DriverLINX Technical Reference Manual* for a list of errors.

Display DriverLINX Message Box Using C/C++

```
//************************************************
// Use this procedure to display DriverLINX messages
//************************************************

UINT ShowDriverLINXMessage (LPServiceRequest pSR)
{
  // Assume caller passed an initialized Service Request
  UINT lastOp;

  lastOp = pSR->operation;      // save current operation
  pSR->operation = MESSAGEBOX;

  UINT result;

  result = DriverLINX(pSR);

  pSR->operation = (Ops)lastOp; // restore last operation code
  return result;
}
```

Display DriverLINX Message Box Using Visual Basic

```
' Use this procedure to display DriverLINX messages

Function ShowDriverLINXMessage(dl As DriverLINXSR) As Integer
  Dim lastOp As Integer
  With dl
    lastOp = .Req_op
    .Req_op = DL_MESSAGEBOX
    .Refresh
    .Req_op = lastOp
    ShowDriverLINXMessage = .Res_result
  End With
End Function
```

Stopping A DriverLINX Task

Applications can use a Service Request to stop a running DriverLINX task. Applications may need to stop a task that is running too long, that a user wants to abort, or that requires a software command to complete. For the counter/timer subsystem, DriverLINX requires that all applications use a stop Service Request to end polled tasks because DriverLINX cannot always detect task completion automatically. DriverLINX can automatically terminate background tasks if the Service Request contains a Stop Event that will eventually become true.

A Stop Service Request must have a valid taskId *property that identifies a previous task. DriverLINX sets* taskId *in the Service Request after successfully starting a task.*

To stop a task, change the *Operation* property of a currently running Service Request to "STOP" and submit the Service Request to DriverLINX. If DriverLINX stops the task, it returns no error in the *Result* property. If the Service Request is not running when the application attempts to stop it, DriverLINX returns a "Service Request not found" error.

Stopping a Task Using C/C++

```
//*********************************************
// Use this procedure to stop any Service Request
//*********************************************

UINT StopDriverLINXTask (LPServiceRequest pSR)
{
  // Use same Service Request from START command
  // Change operation code
  pSR->operation = STOP;

  // Call DriverLINX to perform Service Request
  return DriverLINX(pSR);
}
```

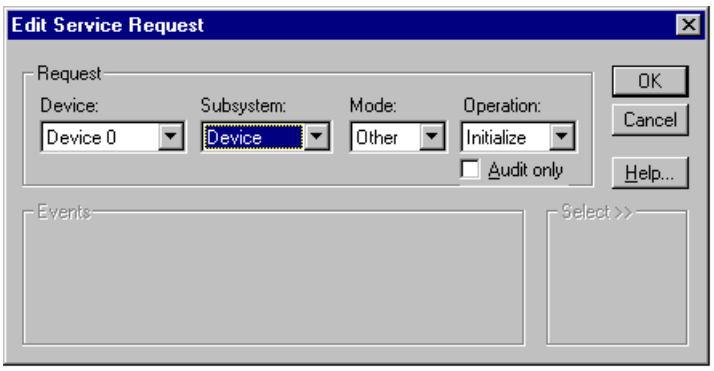
Stopping a Task Using Visual Basic

```
'*********************************************
' Use this procedure to stop any Service Request
'*********************************************

Function StopDriverLINXTask (dl As DriverLINXSR) As Integer
  ' Use same Service Request from DL_START command
  ' Change operation code
  With dl
    .Req_op = DL_STOP
    .Refresh
    StopDriverLINXTask = .Res_result
  End With
End Function
```

Initializing the Device

Device initialization is the first step that all applications should perform after loading a DriverLINX driver. Device initialization cancels all active Service Requests on the device that the current process started and does a software reset of all subsystems. Because DriverLINX supports sharing hardware devices among multiple processes, the additional effects of device initialization vary.

- If the application is the only process using the device, DriverLINX reconfigures and reinitializes the hardware to the user-defined state. If you do not define initialization values for output ports, DriverLINX writes zeros to output ports when the driver first loads and the last known output value at any other Device Initialization.
- If multiple processes are sharing the device, DriverLINX does not reconfigure or reinitialize the hardware state.
- If another process is executing a Service Request on the device, DriverLINX performs initialization steps that will not interfere with the other application and then returns a Device Busy error to app requesting initialization.



To initialize a device, set up the Service Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	DEVICE	OTHER	INITIALIZE

The other properties of a Service Request are unused and should be set to zero.

Initialize the Device Using C/C++

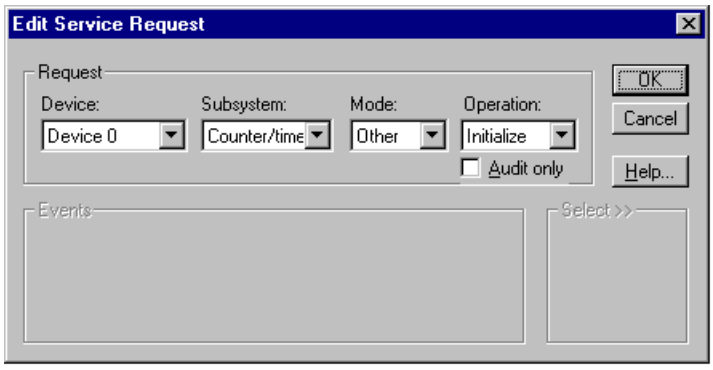
```
//*********************************************
// Use this procedure to initialize the hardware
//*********************************************

UINT InitDriverLINXDevice (LPServiceRequest pSR, UINT Device)
{
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  DL_SetServiceRequestSize(*pSR);

  pSR->hWnd = GetSafeHwnd();
  pSR->device = Device;
  pSR->subsystem = DEVICE;
  pSR->mode = OTHER;
  pSR->operation = INITIALIZE;

  return DriverLINX(pSR);
}
```

Initialize the Device Using Visual Basic

```
' Use this procedure to initialize the hardware

Function InitDriverLINXDevice(dl As DriverLINXSR, ByVal Device As
Integer) As Integer
  With dl
    .Req_device = Device
    .Req_subsystem = DL_DEVICE
    .Req_mode = DL_OTHER
    .Req_op = DL_INITIALIZE
    ' No events, buffers, channels needed
    .Evt_Tim_type = DL_NULLEVENT
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 0
    .Sel_chan_N = 0
    .Refresh
    InitDriverLINXDevice = .Res_result
  End With
End Function
```

Initializing a Counter/Timer Subsystem

Applications may perform a subsystem initialization at any time to abort all outstanding Service Requests that the calling process originally initiated. Usually applications do not need to call this service.



To initialize a subsystem, set up the Service Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	OTHER	INITIALIZE

The other properties of a Service Request are unused and should be set to zero.

Initialize a Subsystem Using C/C++

```
//************************************************************
// Use this procedure to initialize the counter/timer subsystem
//************************************************************

UINT InitCounterTimers (LPServiceRequest pSR, UINT Device)
{
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  DL_SetServiceRequestSize(*pSR);

  pSR->hWnd = GetSafeHwnd();
  pSR->device = Device;
  pSR->subsystem = CT;
  pSR->mode = OTHER;
  pSR->operation = INITIALIZE;

  return DriverLINX(pSR);
}
```

Initialize a Subsystem Using Visual Basic

```
' Use this procedure to initialize the counter/timer subsystem

Function InitCounterTimers(dl As DriverLINXSR, ByVal Device As Integer)
As Integer
  With dl
    .Req_device = Device
    .Req_subsystem = DL_CT
    .Req_mode = DL_OTHER
    .Req_op = DL_INITIALIZE
    ' No events, buffers, channels needed
    .Evt_Tim_type = DL_NULLEVENT
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 0
    .Sel_chan_N = 0
    .Refresh
    InitCounterTimers = .Res_result
  End With
End Function
```

Using Messages and Events

DriverLINX can report task information to your application using the Windows messages or events. See “DriverLINX Events” on page 27 and the on-line *DriverLINX Technical Reference Manual* for more information.

Events for Foreground Tasks

For polled mode tasks, DriverLINX only reports *ServiceStart* and *ServiceDone* events to your application. This provides consistency with the background tasks modes so that if your application uses these events, its logic is the same for foreground and background modes.

If you are trying to use foreground tasks in a fast loop and you are not using these messages, you may wish to tell DriverLINX not to send these messages. This can sometimes increase the speed of the loop.

Disable ServiceStart and ServiceDone Using C/C++

```
//*********************************************************
// Use this procedure to disable SeviceStart and ServiceDone
//*********************************************************

void DisableServiceStartDone (LPServiceRequest pSR)
{
  // Caller sets up Service Request
  pSR->taskFlags |= NO_SERVICESTART | NO_SERVICEDONE;
}
```

Disable ServiceStart and ServiceDone Using Visual Basic

```
'*********************************************************
' Use this procedure to disable SeviceStart and ServiceDone
'*********************************************************

Sub DisableServiceStartDone (dl As DriverLINXSR)
  ' Caller sets up Service Request
  With dl
    .Sel_taskFlags = .Sel_taskFlags Or NO_SERVICESTART Or
NO_SERVICEDONE
  End With
End Sub
```

Events for Background Tasks

By default, DriverLINX sends background tasks *ServiceStart* and *ServiceDone* messages and always sends *DataLost* and *CriticalError* messages if DriverLINX detects any problems. DriverLINX only sends the other messages if the application tells DriverLINX to do so.

Enable and Use Messages Using C/C++

Enable Optional Messages

```
//*********************************************************
// Use this procedure to enable optional DriverLINX messages
//*********************************************************

void EnableAllEvents (LPServiceRequest pSR)
{
  // Caller sets up Service Request
  if (pSR->lpBuffers)
    pSR->lpBuffers->notify |= NOTIFY | NOTIFY_START | NOTIFY_STOP;
}
```

Message Handling in C/C++ or MFC

```
//*******************************************
// C/C++ procedure for using DriverLINX messages
//*******************************************

// Register custom DriverLINX message
UINT gDL_Msg = RegisterWindowMessage(DL_MESSAGE);

// If you're using MFC, then add the following to your classes
// message map:
// BEGIN_MESSAGE_MAP(xxx, yyy)
// ON_REGISTERED_MESSAGE(gDL_Msg, OnDLMessage)
// END_MESSAGE_MAP()
//
// Then change the function below to
// LRESULT OnDLMessage (WPARAM wParam, LPARAM lParam)
// and delete the line:
// if (message == gDL_Msg)

LRESULT OnDLMessage (HWND hWnd, UINT message,
                     WPARAM wParam, LPARAM lParam)
{
  // Was message posted by DriverLINX?
  if (message == gDL_Msg)
    switch (wParam) {
      case DL_SERVICESTART:
        break;
      case DL_SERVICEDONE:
        switch (getSubSystem(lParam)) {
          case CT:
            break;
        } // switch
        break;
      case DL_TIMERTIC:
        break;
      case DL_BUFFERFILLED:
        break;
      case DL_DATALOST:
        break;
      case DL_CRITICALERROR:
        break;
    } // switch
  return 0;
}
```

Enable and Use Messages Using Visual Basic

Enable Optional Events

```
'*****************************************************
' Use this procedure to enable optional DriverLINX events
'*****************************************************

Sub EnableAllEvents (dl As DriverLINXSR)
  ' Caller sets up Service Request
  With dl
    If .Sel_buf_N > 0 Then
      .Sel_buf_notify = .Sel_buf_notify Or DL_NOTIFY Or DL_NOTIFY_START
Or DL_NOTIFY_STOP
    End If
  End With
End Sub
```

Event Handling in Visual Basic

Visual Basic will automatically generate for all DriverLINX events empty subroutines where you can add event-handling logic. See the on-line *DriverLINX/VB Technical Reference Manual* for more details.

Counter Output

Counter/timers generate an output signal when they reach their limit or rollover the count value. When using the Am9513, the application can explicitly program how the counter/timer channel signals the output terminal. The output mode for the 8254 is less flexible and dependent on the hardware's counter mode. DriverLINX supports the outputs shown in "Table 6 Allowed Values for Rate Event Output Property" on page 25.

Applications can also select DriverLINX's default output value for any counter/timer channel. For every counter/timer mode, DriverLINX defines a default output value as shown in the following table:

Generator	Description	Default Output		
		Intel 8254	KPCI-3140	Am9513
RateGen	Periodic rate generator	LoActive	LoToggled	HiActive
SqWave	Square wave generator	HiToggled	LoToggled	Toggled
VDCGen	Variable duty cycle rate generator		LoToggled	HiToggled
BurstGen	Burst rate generator			HiActive
Divider	Frequency divider		LoToggled	HiActive
Freq	Frequency counter			HiActive
Interval	Interval timer			HiActive
Count	Event counter			HiActive
PulseWd	Pulse width measurement			HiActive
SplitClk	Split frequency rate generator			HiActive
FskGen	Frequency-shift keying			Toggled
PulseGen	Pulse generator		LoToggled	Toggled
Retrig RateGen	Retriggerable rate generator			HiActive
Retrig SqWave	Retriggerable square wave generator			Toggled
Count32	32-bit event counter			HiActive
Count64	64-bit event counter			HiActive
Freq32	32-bit frequency counter			HiActive
FreqRatio	Frequency ratio counter			HiActive
OneShot	One-shot pulse or strobe	LoToggled (Mode 0), LoActive (Mode 5)	LoActive	HiActive
Retrig OneShot	Retriggerable one-shot pulse or strobe	LoToggled (Mode 1), LoActive (Mode 4)		HiActive

Table 15 Default Counter/Timer Output Values

Status Polling a Counter/Timer

Applications can monitor the current value and status of one or more counter/timer channels using a Service Request. DriverLINX's handling of status polling for counter/timer subsystem depends on the type of task.

- In non-buffered, polled mode, DriverLINX returns the current counter value and status in the Results Group of the Service Request.
- When using a buffered, polled group task, DriverLINX saves the current counter value in the buffer for each Logical Channel in the group.
- For buffered, interrupt tasks, DriverLINX returns the current buffer number and the position of the next sample to write.

See "Converting Between Counts and Time" on page 58 for how to convert counts to time.

Polling a Counter/Timer Using C/C++

```
//****************************************
// Use this procedure to read a counter/timer
//****************************************

DWORD ReadCounterTimer (LPServiceRequest pSR, UINT* pResult)
{
  UINT        result;

  // Use same Service Request from a Start Service Request
  // Change operation code
  pSR->operation = STATUS;

  // Call DriverLINX to perform Service Request

  result = DriverLINX(pSR);
  if (pResult)
    *pResult = result;
  if (result != NoErr)
    return (DWORD)-1;

  if (pSR->status.u.timerStatus.status == done)
    StopDriverLINXTask(pSR);

  // Return current count
  return pSR->status.u.timerStatus.count;
}
```

Polling a Counter/Timer Using Visual Basic

```
'****************************************
' Use this procedure to read a counter/timer
'****************************************

Function ReadCounterTimer (dl As DriverLINXSR, result As Integer) As
Long
  ' Use same Service Request from a Start Service Request
  With dl
    ' Change operation code
    .Req_op = DL_STATUS
    .Refresh
    result = .Res_result
    If .Res_result <> DL_NoErr Then
      ReadCounterTimer = -1
      Exit Function
    End If
  End With

  If dl.Res_Tim_status = DL_done Then
    StopDriverLINXTask dl
  End If

  ' Return current count
  ReadCounterTimer = dl.Res_Tim_count
End Function
```

Configuring a Counter/Timer Channel

Applications can configure and arm a Logical Channel for a counter/timer without actually starting a task on the counter/timer. This is useful for creating custom counter/timer operations that use multiple counters and for pre-configuring several counter/timer channels that you want to start simultaneously as a group. See "Individual and Group Tasks" on page 29.

When an application configures a counter/timer, DriverLINX initializes the hardware for the requested Logical Channel, but it does not start, or arm, the counter. To start a previously configured counter, the application should add the Logical Channel to the channel list of a group task. See "Controlling Group Tasks" on page 63.

To configure a counter/timer, set up the Service Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	OTHER	CONFIGURE

Set up the Events Group as follows:

Timing	Start	Stop
Rate	None	None

The properties of the timing event control how DriverLINX configures the hardware. A CONFIGURE operation sets the mode of only one counter so, in general, the task-oriented functions cannot be used for the mode. See "Hardware Reference" on page 113 Operating Modes for details on the available modes and the corresponding hardware behavior.

Converting Between Counts and Time

DriverLINX expresses all time units as the number of tics of a board's master clock. The *Period* and *onCount* properties of the Service Request as well as the counter values DriverLINX returns are all in tic units. To make it easy for applications to convert between tic units and seconds, DriverLINX supports two methods:

- **Sec2Tics**—converts time in seconds to hardware tic units.
- **Tics2Sec**—converts time in hardware tic units to seconds.

Time Conversion in C/C++

Sec2Tics

This function converts the time in seconds for a counter/timer Logical Channel to clock tics. The function syntax is

```
DWORD DLLAPI Sec2Tics (UINT device, SubSystems subsystem, UINT
LogicalChannel, float secs);
```

This function returns the result in clock tic units as an unsigned 32-bit word. If the function detects an error, it returns zero.

Parameter	Type/Description
device	**WORD** Specifies the Logical Device of the counter/timer board.
subsystem	**SubSystems** Specifies the counter/timer subsystem.
LogicalChannel	**UINT** Specifies the Logical Channel of the counter/timer. Symbolic values, e.g., DEFAULTTIMER, are acceptable.
Secs	**float** Specifies the time value in seconds to convert to tics.

Tics2Sec

This function converts the time in clock tics for a counter/timer Logical Channel to seconds. The function syntax is

```
BOOL DLLAPI Tics2Sec (UINT device, SubSystems subsystem, UINT
LogicalChannel, DWORD tics, float* pFloat);
```

This function returns TRUE if the conversion was successful, otherwise it returns FALSE. The function returns the converted result at pFloat.

Parameter	Type/Description
device	**UINT** Specifies the Logical Device of the counter/timer board.
subsystem	**SubSystems** Specifies the counter/timer subsystem.
LogicalChannel	**UINT** Specifies the Logical Channel of the counter/timer. Symbolic values, e.g.,

	DEFAULTTIMER, are acceptable.
tics	**DWORD** Specifies the counter/timer value in hardware tics.
pFloat	**float*** Specifies a 32-bit pointer to a singe-precision floating-point variable where DriverLINX stores the converted result in seconds. If an error occurs, the value of this field is undefined.

Time Conversion Using the Custom Control

For the 16-bit VBX, the following functions are DLL exports from "**DrvLnxVB.DLL**". For the ActiveX controls, the functions are control methods.

DLSecs2Tics

This method converts the time in seconds for a counter/timer Logical Channel to clock tics. The method syntax is

```
<control>.DLSecs2Tics (ByVal LogicalChannel As Integer, ByVal secs As
Single) As Long
```

This method returns the result in clock tic units as a 32-bit integer. If the method detects an error, it returns zero.

Parameter	Type/Description
LogicalChannel	**Integer** Specifies the Logical Channel of the counter/timer. Symbolic values, e.g., DL_DEFAULTTIMER, are acceptable.
Secs	**Single** Specifies the time value to convert in seconds.

DLTics2Secs

This method converts the time in clock tics for a counter/timer Logical Channel to seconds. The method syntax is

```
<control>.DLTics2Secs (ByVal LogicalChannel As Integer, ByVal tics As
Long) As Single
```

This method returns the converted time in seconds. If an error occurs, DriverLINX returns 0.0.

Parameter	Type/Description
LogicalChannel	**Integer** Specifies the Logical Channel of the counter/timer. Symbolic values, e.g., DL_DEFAULTTIMER, are acceptable.
tics	**Long** Specifies the counter/timer value in hardware tics.

Using Background Tasks

DriverLINX can run counter/timer tasks in the background asynchronously collecting data while the application processes other data in the foreground. DriverLINX can support asynchronous mode only if the counter/timer board supports interrupts, and you have configured the board to use an available interrupt.

Background, interrupt-driven tasks can either report an event to the application at each interrupt or they can use a data buffer to collect samples at each interrupt.

Using a Counter/Timer to Generate Clock Messages

DriverLINX can post a "timer tic" message or event to an application at each interrupt by a counter/timer channel if the Service Request does not specify any data buffers. See "DriverLINX Events" on page 27.

To start a counter/timer generating an interrupt, set up the Request Group in a Service Request as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	INTERRUPT	START

Set up the Events Group as follows:

Timing	Start	Stop
Rate	None	None

Then set up the timing event using any of the single counter/timer Rate Events described in this manual or in "Hardware Reference" on page 113 Operating Modes.

To create a simple, periodic clock on any available Logical Channel, use the following setup for a Rate Event:

Mode	Period	Gate	Pulses
RATEGEN	period	DISABLED	0

Note that Windows or your application cannot keep up with the highest interrupt rate the counter/timer can generate. At moderately high rates, your application message queue may overflow and timer tics will be lost. At very high interrupt rates, Windows will skip interrupts and may become very sluggish or unstable.

To create a single timer tic message after a known interval, use the following setup for a Rate Event:

Mode	Period	Gate	Pulses
ONESHOT	period	DISABLED	1

Note that the counter/timer hardware design only allows DriverLINX to support timer tics on one running counter/timer at a time.

Storing the Counter/Timer Value at Each Interrupt

DriverLINX can store the current value of a counter/timer into a memory buffer at each interrupt.

Note that Windows or your application cannot keep up with the highest interrupt rate the counter/timer can generate. At high interrupt rates, Windows will skip interrupts and may become very sluggish or unstable.

To start a counter/timer generating an interrupt, set up the Request Group in a Service Request as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	INTERRUPT	START

Set up the Events Group as follows:

Timing	Start	Stop
Rate or Digital	Command or Digital	Terminal Count or Command or Digital

The Timing Event specifies the pacing or interrupt source.

- Rate Events use a counter/timer channel to generate an interrupt source. Use any of the single counter/timer modes described in “Hardware Reference” on page 113 Operating Modes.
- Digital Events use the hardware’s external interrupt input line as the interrupt source. See “Using the External Interrupt Input Line” on page 62.

To create a simple, periodic clock on any available Logical Channel, use the following setup for a Rate Event:

Mode	Period	Gate	Pulses
RATEGEN	period	DISABLED	0

The Start and Stop Events determine when the DriverLINX task starts and stops saving counter values at each interrupt.

- **Command**—starts or stops the task on software command.
- **Digital**—starts or stops the task when the masked digital input satisfies the pattern matching condition in the event. See "Using Digital Start and Stop Events" on page 63.
- **Terminal Count**—stops the task DriverLINX has filled the buffers with count values once.

DriverLINX can optionally post "buffer filled" messages to the application as DriverLINX completes processing each buffer. See "DriverLINX Events" on page 27.

To start or stop data transfer on software command, use Command Events for the Start or Stop Event. If you use a Stop Command or Digital Event, after DriverLINX finishes processing the last buffer, it will automatically start writing data again into the first buffer. With a Stop Command, DriverLINX will acquire data until the application resets the Service Request's *Operation* property to Stop and resubmits the Service Request to DriverLINX.

Select Buffers

Set the number of Buffers between 1 and 255 and the *BufferSize* property to the number of bytes to transfer. Buffers must contain an integral multiple of the total number of channels specified in the Service Request. DriverLINX can optionally post "buffer filled" messages to the application as DriverLINX completes processing each buffer. See "DriverLINX Events" on page 27.

Using the External Interrupt Input Line

DriverLINX has no software control over the CTM's external interrupt enable input.

Use a Digital Timing Event to tell DriverLINX which external hardware input source to use for the interrupt. DriverLINX models the external hardware interrupt lines as 1-bit digital input ports. Set up the Digital Event as follows:

Channel	Mask	Match	Pattern
<external interrupt channel>	<input lines to test>	FALSE or "not equal"	0

- For the Channel, either specify the Logical Channel DriverLINX has assigned as the external interrupt input line (see the Logical Device Descriptor) or use a hardware-independent, symbolic Logical Channel, *DI_EXTCLK*. DriverLINX automatically replaces this value with the correct hardware channel when the app sends the Service Request to DriverLINX.
- Use the *Mask* property to indicate which line(s) to enable for interrupts. Most boards only support one external interrupt line so use a value of 1.
- Set the *Match* and *Pattern* properties to "not equal zero". This specifies that a rising edge at any input will trigger the interrupt. Other values for these properties will generate an error.

Using Digital Start and Stop Events

DriverLINX can optionally post "start trigger" and "stop trigger" messages to the application. See the on-line DriverLINX Technical Reference Manual for more information about messages.

To start or stop data transfer when a certain condition occurs on a digital input channel, use a Digital Event for the Start or Stop Event. At each interrupt, DriverLINX tests the requested Logical Channel for the trigger event. If DriverLINX detects the start trigger, it starts processing the data buffers immediately. After processing one sample or scan, DriverLINX tests for the stop trigger event, and, if found, stops processing data immediately. Note that a digital input may change value between the time the interrupt occurs and when DriverLINX reads the Logical Channel for a trigger.

Set up a Digital Event as follows:

Channel	Mask	Match	Pattern
<Logical Channel>	<input lines to test>	0 - "not equal" or 1 - "equal"	<pattern to match>

- For the *Channel* property, specify the Logical Channel for any digital input port.
- Use the *Mask* property to select which input bits to test as a digital trigger.
- Use the *Match* property to select how DriverLINX tests for a digital trigger.
- Use the *Pattern* property to specify the bits DriverLINX uses for comparison.

DriverLINX supports two types of digital triggers tests based on the value of the *Match* property.

Match Value	Trigger Test
0 — Not Equals	Channel **AND** Mask != Pattern
1 — Equals	Channel **AND** Mask == Pattern

With a Stop Digital Event, DriverLINX will terminate acquisition either when the digital input value satisfies the digital trigger condition or when the application sends a stop operation.

If the *Delay* property of a Digital Event is not zero, DriverLINX will not trigger the event until it has counted the number of additional interrupts the app specified in the *Delay* property. As a special case, if the stop *Delay* property has the maximum count, DriverLINX treats this event as "stop on command", but it will send a message to the application each time it detects the stop event.

Controlling Group Tasks

Group tasks give your application more control over the counter/timer subsystem. It can configure counter/timers in any basic mode that the hardware supports, and start or stop multiple counter/timers at the same time. You can create polled mode groups and interrupt mode groups. For polled mode groups, DriverLINX starts or stops all counter/timers at the same time. Applications can poll the status of counter/timers in

the group while the task is running. For interrupt mode groups, DriverLINX also starts or stops all counter/timers at the same time, but DriverLINX writes the current counter/timer values into a buffer at each interrupt. The trade-off is that your application must perform its own analysis of the buffers as DriverLINX cannot discern the aggregate function of your group task.

To use a group task, you must first individually configure the counter/timers you wish to use in a group. To configure a Logical Channel, you set up the Logical Channel with the same properties you would normally use for a basic counter/timer task, but you must change the *Operation* property from "Start" to "Configure". See "Configuring a Counter/Timer Channel" on page 57 and "Hardware Reference" on page 113 Operating Modes.

To designate Logical Channels as members of a group, set up a Service Request and use the Select Channels Group to specify the Logical Channels in the group.

Select Channels

To tell DriverLINX which Logical Channels are members of the group task, use the Select Channels Group properties. You can specify a group consisting of a single channel, a range of channels, or a list of channels.

To set up the Select Channels Group for one Logical Channel:

Number of channels	Start Channel	Format
1	<Logical Channel>	native

To set up the Select Channels Group for a consecutive range of channels:

Number of channels	Start Channel	Stop Channel	Format
2	<Logical Channel>	<Logical Channel>	native

Specify the number of channels as 2, not the number of channels in the consecutive sequence.

DriverLINX scans all channels between the starting and stopping channel. If the starting channel is greater than the stopping channel, the channel sequence wraps around at the highest Logical Channel and continues from zero.

To set up the Select Channels Group for a random channel list:

Number of channels	$Channel_i$	$Gain_i$	Format
<size of list>	<Logical Channel>	0	native

DriverLINX can transfer one Logical Channel at each interrupt or transfer all the specified Logical Channels (a scan) at each interrupt. The *Simultaneous* property tells DriverLINX to transfer either one channel (unchecked or false) or all channels (checked or true) at each interrupt. Most counter/timer hardware does not support true simultaneous transfers, so DriverLINX rapidly reads each channel in a loop.

Polled Mode Groups

In a preemptive multitasking system, the delay between two instructions can vary significantly and unpredictably.

For a polled mode group, DriverLINX ideally starts or stops all counter/timers in the group using a single hardware operation. However, some hardware does not support this for all Logical Channels. The CTM-10 uses one Am9513 chips to control Logical Channels 0 to 4 and another chip for Logical Channels 5 to 9. In this case, DriverLINX must use two separate instructions to control each chip. For boards that use an 8254 chip, DriverLINX must use a separate instruction for each Logical Channel.

To start a polled mode group, set up the Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	POLLED	START

Set up the Events Group as follows:

Timing	Start	Stop
None	None	None

The Service Request needs no Timing Event as each counter/timer in a group runs independently. See “Select Channels” on page 64 for how to specify the Logical Channels for a group.

If you need to read the current counter values of channels in a group, set up a single buffer with one sample for each Logical Channel in the Service Request. When your application performs status polling with the Service Request (see “Status Polling a Counter/Timer” on page 56), DriverLINX will store the current counter value of every channel in the Service Request into the buffer rather than returning a single value in the Service Request. If your application does not need status polling, set the number of buffers to zero in the Service Request.

Starting a Polled Mode Group Using C/C++

Note that the following C example will cause memory leaks unless the calling application takes responsibility for freeing the following memory after stopping the Service Request for the group task:

- Channel Gain List in the Service Request
- Buffer List in the Service Request
- Buffers in the Service Request’s Buffer List

```
//*****************************************************
// Use this procedure to start a polled mode group task
//*****************************************************

UINT StartPolledGroup (LPServiceRequest pSR,
                       UINT LogicalDevice,
                       UINT nChannels,
                       int channels[])
{
  // Set up Service Request to perform task

  // First zero Service Request structure
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  // Then initialize structure size
  DL_SetServiceRequestSize(*pSR);

  // Set up Request Group of Service Request
  pSR->hWnd = GetSafeHwnd();
  pSR->device = LogicalDevice;
  pSR->subsystem = CT;
  pSR->mode = POLLED;
  pSR->operation = START;

  // Set up channel list
  pSR->channels.nChannels = nChannels;
  if (pSR->channels.nChannels) {
    pSR->channels.chanGainList =
                (LPCHANGAIN)malloc(nChannels * sizeof(CHANGAIN));
    // N.B. Caller must free this memory
    if (pSR->channels.chanGainList)
      // Zero structure
      memset(pSR->channels.chanGainList, 0,
             pSR->channels.nChannels * sizeof(CHANGAIN));
    else
      pSR->channels.nChannels = 0;
    for (UINT i = 0; i < pSR->channels.nChannels; ++i) {
      pSR->channels.chanGainList[i].channel =
                                     (SINT)channels[i];
      pSR->channels.chanGainList[i].gainOrRange = 0;
    } // for
  }

  // Set up optional buffer list for status readback
  // A buffer list isn't required if you don't need
  // per channel status info
  if (pSR->channels.nChannels) {
    pSR->lpBuffers = (LPBUFFLIST)malloc(DL_BufferListBytes(1));
    // N.B. Caller must deallocate buffer list memory
    if (pSR->lpBuffers) {
      // Zero structure
      memset(pSR->lpBuffers, 0, sizeof(DL_BUFFERLIST));
      pSR->lpBuffers->nBuffers = 1;
      // Always use 1 buffer for status polling
      // Allocate 1 element per channel
      pSR->lpBuffers->bufferSize =
                                sizeof(WORD) * pSR->channels.nChannels;
      // Let DriverLINX allocate memory for data-acq buffers
      pSR->lpBuffers->BufferAddr[0] =
                     BufAlloc(GBUF_POLLED, pSR->lpBuffers->bufferSize);
      // N.B. Caller must deallocate buffer memory using BufFree
    } // if
  } // if

  // Call DriverLINX to perform Service Request
  return DriverLINX(pSR);
}
```

Starting a Polled Mode Group Task Using Visual Basic

```
'*****************************************************
' Use this procedure to start a polled mode group task
'*****************************************************
Function StartPolledGroup (dl As DriverLINXSR, ByVal LogicalDevice As
Integer, ByVal nChannels As Integer, Channels() As Integer) As Integer
  ' Set up Service Request to perform task
  Dim i As Integer
  With dl
    .Req_device = LogicalDevice
    .Req_subsystem = DL_CT
    .Req_mode = DL_POLLED
    .Req_op = DL_START

    ' Events are not required
    .Evt_Tim_type = DL_NULLEVENT
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT

    ' Set up optional buffer list for status readback
    ' A buffer list isn't required if you don't need
    ' per channel status info
    .Sel_buf_N = 1
    .Sel_buf_samples = nChannels

    ' Set up channel list
    .Sel_chan_format = DL_tNATIVE
    .Sel_chan_N = nChannels
    For i = 0 to nChannels - 1
      .Sel_chan_list(i) = Channels(i)
      .Sel_chan_gainCodeList(i) = 0
    Next i

    .Refresh
    StartPolledGroup = .Res_result
  End With
End Function
```

Interrupt Mode Groups

In a preemptive multitasking system, the delay between two instructions can vary significantly and unpredictably.

For an interrupt mode group, DriverLINX ideally starts or stops all counter/timers in the group using a single hardware operation. However, some hardware does not support this for all Logical Channels. The CTM-10 uses one Am9513 chips to control Logical Channels 0 to 4 and another chip for Logical Channels 5 to 9. In this case, DriverLINX must use two separate instructions to control each chip. For boards that use an 8254 chip, DriverLINX must use a separate instruction for each Logical Channel.

To start an interrupt mode group, set up the Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	INTERRUPT	START

Set up the Events Group as follows:

Timing	Start	Stop
Digital or	Command or	Command or

Rate	Digital	Digital or Terminal Count

DriverLINX uses the Timing Event as the interrupt source that it uses to read the current counter value of each counter/timer in the channel list into the data buffers. If you wish to also read the current value of the interrupt counter/timer, include its Logical Channel number in the channel list for the Service Request. See “Select Channels” on page 64 for how to specify the Logical Channels for a group.

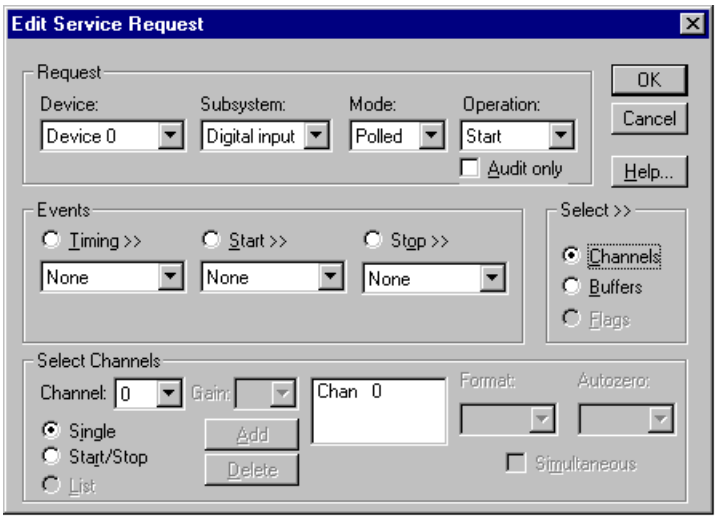
To use the external interrupt input line, see “Using the External Interrupt Input Line” on page 62.

See “Using Digital Start and Stop Events” on page 63 for how to set up the Start and Stop Events for an interrupt group task.

Using Digital I/O Tasks

Reading or Writing a Single Digital Value

Applications can read or write a single value for a digital port using a Service Request for the digital input or output subsystem.



To transfer a single value, set up the Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	<Digital Subsystem>	POLLED	START

Set up the Events Group as follows:

Timing	Start	Stop
None	None or Command	None or Terminal Count

For a Start Event, None and Command are equivalent for a Start Event as are None and Terminal Count for a Stop Event. Start on Command and stop on Terminal Count tells DriverLINX to transfer the data once.

Select Channels

Set up the Select Group Channels as follows:

Number of channels	Start Channel	Format
1	<Logical Channel>	native

Select Buffers

Single-value transfers use *ioValue* property in the Service Request instead of a buffer to hold the data. Set the number of Buffers to zero. For output, assign the value to write to the *ioValue* property in the Results Group. For input, read the input from the *ioValue* property after executing the Service Request.

To write a single value, set up the Status Group of the Service Request as follows:

Type	ioValue
IOVALUE	<value>

Read or Write a Single Value Using C/C++

Write a Single Value

```
//****************************************
// Use this procedure to write a single value
// to a specific channel
//****************************************

UINT WriteChannel (LPServiceRequest pSR, UINT Device,
                   UINT Channel, DWORD Value)
{
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  DL_SetServiceRequestSize(*pSR);

  pSR->hWnd = GetSafeHwnd();
  pSR->device = Device;
  pSR->subsystem = DO;
  pSR->mode = POLLED;
  pSR->operation = START;

  pSR->channels.nChannels = 1;
  pSR->channels.chanGain[0].channel = Channel;

  pSR->status.typeStatus = IOVALUE;
  pSR->status.u.ioValue = Value;

  return DriverLINX(pSR);
}
```

Read a Single Value

```
//************************************
// Use this procedure to read one value
// from a specific channel
//************************************

DWORD ReadChannel (LPServiceRequest pSR, UINT Device, UINT Channel,
                   UINT* pResult)
{
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  DL_SetServiceRequestSize(*pSR);

  pSR->hWnd = GetSafeHwnd();
  pSR->device = Device;
  pSR->subsystem = DI;
  pSR->mode = POLLED;
  pSR->operation = START;

  pSR->channels.nChannels = 1;
  pSR->channels.chanGain[0].channel = Channel;

  UINT result;
  result = DriverLINX(pSR);
  if (pResult)
    *pResult = result;
  if (result != NoErr)
    return (DWORD)-1;

  return pSR->status.u.ioValue;
}
```

Read or Write a Single Value Using Visual Basic

Write a Single Value

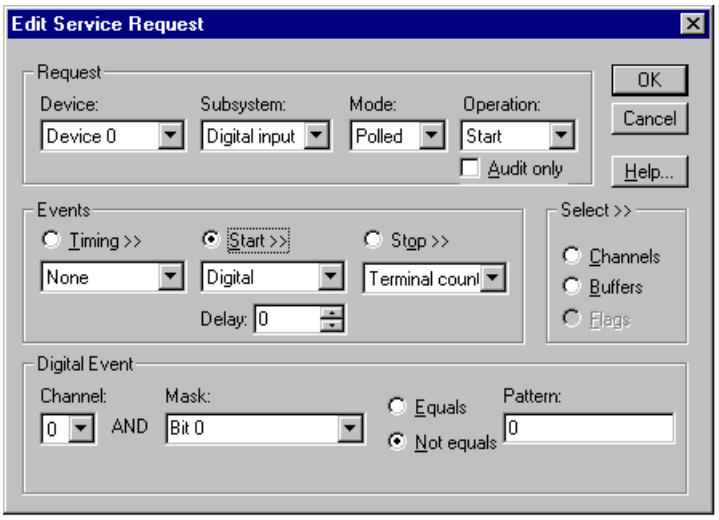
```
' Use this procedure to write one sample
' to a specific channel

Function WriteChannel(dl As DriverLINXSR, ByVal Channel As Integer,
ByVal Value As Integer) As Integer
  Dim Res%
  With dl
     .Req_subsystem = DL_DO
     .Req_mode = DL_POLLED
     .Req_op = DL_START
     .Evt_Tim_type = DL_NULLEVENT
     .Evt_Str_type = DL_NULLEVENT
     .Evt_Stp_type = DL_NULLEVENT
     .Sel_buf_N = 0
     .Sel_chan_format = DL_tNATIVE
     .Sel_chan_N = 1
     .Sel_chan_start = Channel
     .Res_Sta_ioValue = Value
     .Refresh
    WriteChannel = .Res_result
  End With
End Function
```

Read a Single Value

```
' Use this procedure read one sample
' from a specific channel

Function ReadChannel(dl As DriverLINXSR, ByVal Channel As Integer,
result As Integer) As Integer
' Set up for polled digital input of 1 sample
With dl
    .Req_subsystem = DL_DI
    .Req_mode = DL_POLLED
    .Req_op = DL_START
    .Evt_Tim_type = DL_NULLEVENT
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 0
    .Sel_chan_format = DL_tINTEGER
    .Sel_chan_N = 1
    .Sel_chan_start = Channel
    .Refresh
    result = .Res_result
  End With
  If dl.Res_result = DL_NoErr Then
    ReadChannel = dl.Res_Sta_ioValue
  End If
End Function
```

Reading or Writing Specific Digital Bits

Applications can write specific bits to a digital port using a Digital Event to supply a bit mask. Use this technique to set single bits in an output port or to share an output port between threads or processes.



Setting up masked I/O is similar to single value transfers. First, set up the Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	<Digital Subsystem>	POLLED	START

Set up the Events Group as follows:

Timing	Start	Stop
None	Digital	None or Terminal Count

For a Stop Event, None or Terminal Count are equivalent.

Start Event

Set up the Digital Event as follows:

Channel	Mask	Match	Pattern
<Logical Channel>	<bit mask>	<unused>	<unused>

DriverLINX composes the new output value for the port as

new value = (old value **AND NOT** Mask) **OR** (user value **AND** Mask).

Select Channels

Set up the Select Group Channels as follows:

Number of channels	Start Channel	Format
1	<Logical Channel>	native

Select Buffers

Single-value transfers use *ioValue* property in the Service Request instead of a buffer to hold the data. Set the number of Buffers to zero. For output, assign the value to write to the *ioValue* property in the Results Group. For input, read the input from the *ioValue* property after executing the Service Request.

To write a single value, set up the Status Group of the Service Request as follows:

Type	ioValue
IOVALUE	<value>

Write a Masked Value Using C/C++

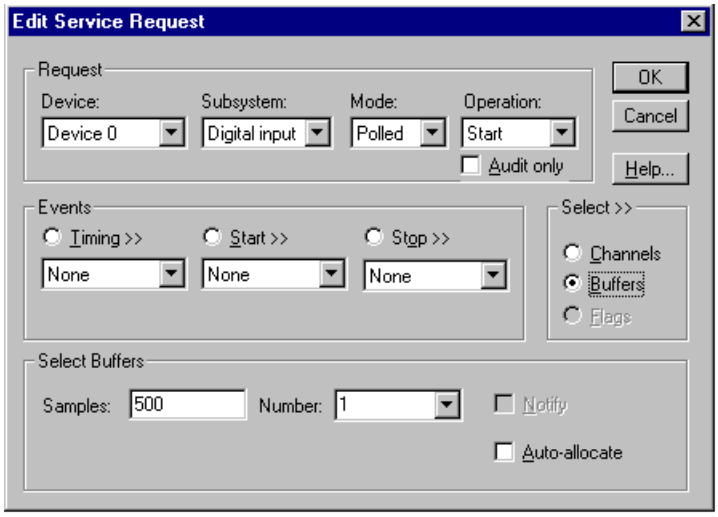
```
//*****************************************************
// Use this procedure to read one value from a specific
// channel
//*****************************************************

UINT WriteBits (LPServiceRequest pSR, UINT Device, UINT Channel, UINT
Value, UINT Mask)
{
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  DL_SetServiceRequestSize(*pSR);

  pSR->hWnd = GetSafeHwnd();
  pSR->device = Device;
  pSR->subsystem = DO;
  pSR->mode = POLLED;
  pSR->operation = START;

  pSR->start.typeEvent = DIEVENT;
  pSR->start.u.diEvent.channel = Channel;
  pSR->start.u.diEvent.mask = Mask;
  pSR->start.u.diEvent.match = FALSE;
  pSR->start.u.diEvent.pattern = 0;

  pSR->channels.nChannels = 1;
  pSR->channels.chanGain[0].channel = Channel;

  pSR->status.typeStatus = IOVALUE;
  pSR->status.u.ioValue = Value;

  return DriverLINX(pSR);
}
```

Write a Masked Value Using Visual Basic

```
Function WriteBits(dl As DriverLINXSR, ByVal Channel As Integer, ByVal
Value As Integer, ByVal Mask As Integer)As Integer
  ’ Set up for polled digital output of 1 sample
  With dl
    .Req_subsystem = DL_DO
    .Req_mode = DL_POLLED
    .Req_op = DL_START
    .Evt_Tim_type = DL_NULLEVENT
    .Evt_Str_type = DL_DIEVENT
    .Evt_Str_diChannel = Channel
    .Evt_Str_diMask = Mask
    .Evt_Str_diMatch = DL_NotEquals
    .Evt_Str_diPattern = 0
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 0
    .Sel_chan_format = DL_tNATIVE
    .Sel_chan_N = 1
    .Sel_chan_start = Channel
    .Res_Sta_ioValue = Value
    .Refresh
    WriteBits = .Res_result
  End With
End Function
```

Rapidly Transferring a Block of Digital Data

Applications can rapidly transfer a single data buffer of values to or from a digital I/O port using the computer's block I/O hardware instructions. Note that not all hardware boards are able to sustain the I/O transfer rate on faster computers.



To transfer a buffer, set up the Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	<Logical Subsystem>	POLLED	START

Set up the Events Group as follows:

Timing	Start	Stop
None	None or Command	None or Terminal Count

For a Start Event, None and Command are equivalent for a Start Event as are None and Terminal Count for a Stop Event. Start on Command and stop on Terminal Count tells DriverLINX to transfer the data in buffer once.

Select Channels

Set up the Select Group Channels as follows:

Number of channels	Start Channel	Format
1	<Logical Channel>	native

Select Buffers

Set the number of Buffers to one and the *BufferSize* to the number of bytes to transfer.

Read or Write a Single Buffer Using C/C++

Read One Buffer

```
//*********************************
// Use this procedure to read a data
// array from a specific channel
//*********************************

UINT ReadChannelBuff (LPServiceRequest pSR, UINT Device, UINT Channel,
                      PVOID Buffer, DWORD Length)
{
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  DL_SetServiceRequestSize(*pSR);

  pSR->hWnd = GetSafeHwnd();
  pSR->device = Device;
  pSR->subsystem = DI;
  pSR->mode = POLLED;
  pSR->operation = START;

  pSR->channels.nChannels = 1;
  pSR->channels.chanGain[0].channel = Channel;

  pSR->lpBuffers = (LPBUFFLIST)malloc(DL_BufferListBytes(1));
  // N.B. Caller must deallocate buffer list memory
  if (!pSR->lpBuffers)
    return Error(Abort, BufAllocErr);

  pSR->lpBuffers->nBuffers = 1;
  pSR->lpBuffers->bufferSize = Length;
  pSR->lpBuffers->BufferAddr[0] = Buffer;

  return DriverLINX(pSR);
}
```

Write One Buffer

```
//**********************************
// Use this procedure to write a data
// array to a specific channel
//**********************************

UINT WriteChanBuf (LPServiceRequest pSR, UINT Device, UINT Channel,
                   PVOID Buffer, DWORD Length)
{
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  DL_SetServiceRequestSize(*pSR);

  pSR->hWnd = GetSafeHwnd();
  pSR->device = Device;
  pSR->subsystem = DO;
  pSR->mode = POLLED;
  pSR->operation = START;

  pSR->channels.nChannels = 1;
  pSR->channels.chanGain[0].channel = Channel;

  pSR->lpBuffers = (LPBUFFLIST)malloc(DL_BufferListBytes(1));
  if (!pSR->lpBuffers)
    return Error(Abort, BufAllocErr);

  pSR->lpBuffers->nBuffers = 1;
  pSR->lpBuffers->bufferSize = Length;
  pSR->lpBuffers->BufferAddr[0] = Buffer;

  UINT        result;
  result = DriverLINX(pSR);

  if (pSR->lpBuffers) {
    free(pSR->lpBuffers);
    pSR->lpBuffers = 0;
  }

  return result;
}
```

Read or Write a Single Buffer Using Visual Basic

Read One Buffer

```
' Use this procedure to read one buffer from a
' specific channel.

Function ReadChannelBuff(dl As DriverLINXSR, ByVal Channel As Integer,
Buffer() As Byte, ByVal Length As Integer)As Integer
  ' Set up for polled digital input
With dl
    .Req_subsystem = DL_DI
    .Req_mode = DL_POLLED
    .Req_op = DL_START
    .Evt_Tim_type = DL_NULLEVENT
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 1
    .Sel_buf_size = dl.DLSamples2Bytes(Channel, Length)
    .Sel_chan_format = DL_tINTEGER
    .Sel_chan_N = 1
    .Sel_chan_start = Channel
    .Refresh
    ReadChannelBuff = .Res_result
  End With
  If dl.Res_result = DL_NoErr Then
    Dim dummy As Integer
    dummy = .VBArrayBufferXfer(0, Buffer, DL_BufferToVBArray)
  End If
End Function
```

Write One Buffer

```
' Use this procedure write an integer data
' array to a specific channel

Function WriteChanBuf(dl As DriverLINXSR, ByVal Channel As Integer,
Buffer() As Byte, ByVal Length As Integer)As Integer
  Dim I As Integer, dummy As Integer
  With dl
    .Req_subsystem = DL_DO
    .Req_mode = DL_POLLED
    .Req_op = DL_START
    .Evt_Tim_type = DL_NULLEVENT
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 1
    .Sel_buf_size = dl.DLSamples2Bytes(Channel, Length)
    dummy = .VBArrayBufferXfer(0, Buffer, DL_VBArrayToBuffer)
    .Sel_chan_format = DL_tNATIVE
    .Sel_chan_N = 1
    .Sel_chan_start = Channel
    .Refresh
    WriteChanBuf = .Res_result
  End With
End Function
```

Using Task-Oriented Functions

DriverLINX's Task-Oriented Functions

DriverLINX defines several useful task-oriented counter/timer functions that can be support on most counter/timer hardware. These tasks define common counter/timer functions in generic terms so they are portable across data-acquisition boards with similar features. Using one of these tasks makes your application independent of the particular counter/timer chip a board uses.

Event Counting

Event counting is the simplest counter/timer function. The counter/timer counts source edges at the **Clock** input and the application reads the current count value. In polled mode, the application reads the count value by using *Status* commands.

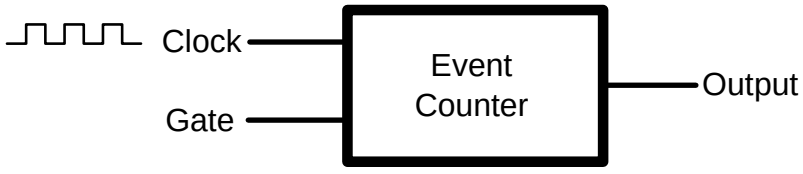


Figure 2 Event Counting

Each Am9513 chip has five counter/timer channels. When advancing to the next higher channel, the hardware wraps around from the last to first channel.

DriverLINX supports 16-, 32-, and 64-bit wide counters using 1, 2, or 4 counter/timer channels, respectively. When using multiple counter/timer channels, the application's Service Request specifies the counter/timer channel where the user has attached the input source, and DriverLINX then automatically uses consecutive counter/timer channels for the high-order count.

Starting an Event Counter

To start a software-polled event counter, set up the Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	POLLED	START

Set up the Events Group as follows:

Timing	Start	Stop
Rate	None or Command	None or Terminal Count

To set up the Timing Event, see “Specifying the Rate Event for Event Counting” on page 80. DriverLINX does not need Start or Stop events for event counting, but the application may optionally specify Command and Terminal Count for Start and Stop events, respectively. For a Service Request that does not specify data buffers, None and Command are equivalent for a Start Event as are None and Terminal Count for a Stop Event.

Specifying the Rate Event for Event Counting

*You can determine the first overflow by physically connecting a toggled **Output** to a digital input and polling the digital input.*

DriverLINX’s default output value for all event counters is active-high terminal count pulse.

DriverLINX supports repetitive and non-repetitive event counting with several gating options as shown in the following tables for 16-, 32-, and 64-bit counting. When repetitive counters reach the maximum count, they wrap around to zero and continue counting without any indication of overflow. When non-repetitive counters reach the maximum count, they wrap around to zero and stop with a count of one.

To set up an event counter, select the type of counter from the following tables and program the *Rate Generator* properties in a Service Request as specified. Unused or unspecified properties should be set to zero. Applications can set the Rate Generator’s *Output* property to any value. See “Counter Output” on page 55.

Am9513

In the following tables, the Am9513 Mode column refers to the Advanced Micro Devices’ letter designation for the hardware mode that DriverLINX uses to implement the counter function. See “Am9513 Operating Modes” on page 117 for information about hardware modes.

16-bit Counting	Am9513 Mode	Channel	Mode	Clock	Gate	Pulses
Repetitive counting with no hardware gating	D	N	COUNT	<source>	DISABLED	0
Non-repetitive counting with no hardware gating	A	N	COUNT	<source>	DISABLED	1
Repetitive counting with level gating	E	N	COUNT	<source>	level	0
Non-repetitive counting with level gating	B	N	COUNT	<source>	level	1
Repetitive counting with edge triggering	F	N	COUNT	<source>	edge	0
Non-repetitive counting with edge triggering	C	N	COUNT	<source>	edge	1
Repetitive counting with hardware retriggering	Q	N	RETRIG COUNT	<source>	level	0

Table 16 Rate Event Properties for 16-bit Event Counting

32-bit Counting	Am9513 Mode	Channel	Mode	Clock	Gate	Pulses
Repetitive counting with no hardware gating	D, D	N..N+1	COUNT32	<source>	DISABLED	0
Non-repetitive counting with no hardware gating	D, A	N..N+1	COUNT32	<source>	DISABLED	1
Repetitive counting with level gating	E, D	N..N+1	COUNT32	<source>	level	0

Table 17 Rate Event Properties for 32-bit Event Counting

64-bit Counting	Am9513 Mode	Channel	Mode	Clock	Gate	Pulses
Repetitive counting with no hardware gating	D, D, D, D	N..N+3	COUNT64	<source>	DISABLED	0

Table 18 Rate Event Properties for 64-bit Event Counting

KPCI-3140

In the following tables, the KPCI-3140 Mode column refers to the hardware mode that DriverLINX uses to implement the counter function. See “KPCI-3140 Operating Modes” on page 116 for information about hardware modes.

16-bit Counting	KPCI-3140 Mode	Channel	Mode	Clock	Gate	Pulses
Repetitive counting with no hardware gating	2	N	COUNT	<source>	DISABLED	0
Non-repetitive counting with no hardware gating	0	N	COUNT	<source>	DISABLED	1
Repetitive counting with level gating	2	N	COUNT	<source>	level	0
Non-repetitive counting with edge triggering	0	N	COUNT	<source>	edge	1

Table 19 Rate Event Properties for 16-bit Event Counting

32-bit Counting	KPCI-3140 Mode	Channel	Mode	Clock	Gate	Pulses
Repetitive counting with no hardware gating	2, 2	N..N+1	COUNT32	<source>	DISABLED	0
Repetitive counting with level gating	2, 2	N..N+1	COUNT32	<source>	level	0

Table 20 Rate Event Properties for 32-bit Event Counting

64-bit Counting	KPCI-3140 Mode	Channel	Mode	Clock	Gate	Pulses
Repetitive counting with no hardware gating	2, 2, 2, 2	N..N+3	COUNT64	<source>	DISABLED	0
Repetitive counting with level gating	2, 2, 2, 2	N..N+3	COUNT64	<source>	level	0

Table 21 Rate Event Properties for 64-bit Event Counting

Hardware Setup for Event Counting

The Am9513 supports counting any source or gate input as well as the previous counter's terminal count and the internal frequency divider.

For event counting, the application specifies the Logical Channel, N, of the base counter in the Service Request. The user attaches the count source to the terminal the application specifies in the Service Request **Clock** property. Depending on the counting Mode, the user optionally attaches a triggering or gating signal to the **Gate** input.

Channel	Clock	Gate	Output
N	count source	see tables	
N+m			any

When using multiple counter/timer channels, the application's Service Request specifies the base counter/timer, and DriverLINX then automatically uses consecutive counter/timer channels for the higher-order count.

Event Counting Using C/C++

```
//************************************
// Use this procedure for event counting
//************************************

UINT StartEventCount (LPServiceRequest pSR, UINT LogicalDevice,
                      UINT LogicalChannel, CLOCKS source,
                      GATESTATUS gate, UINT clkOut,
                      BOOLEAN continuous)
{
  // Set up Service Request to perform task

  // First zero Service Request structure
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  // Then initialize structure size
  DL_SetServiceRequestSize(*pSR);

  // Set up Request Group of Service Request
  pSR->hWnd = GetSafeHwnd();
  pSR->device = LogicalDevice;
  pSR->subsystem = CT;
  pSR->mode = POLLED;
  pSR->operation = START;

  // Set up Timing Event
  pSR->timing.typeEvent = RATEEVENT;
  pSR->timing.u.rateEvent.channel = LogicalChannel;
  pSR->timing.u.rateEvent.mode = COUNT; // or COUNT32 or COUNT64
  pSR->timing.u.rateEvent.clock = source;
  pSR->timing.u.rateEvent.gate = gate;
  pSR->timing.u.rateEvent.period = 0;
  pSR->timing.u.rateEvent.onCount = 0;
  pSR->timing.u.rateEvent.pulses = continuous ? 0 : 1;
  pSR->timing.u.rateEvent.pulses |= clkOut;

  // Call DriverLINX to perform Service Request
  return DriverLINX(pSR);
}
```

Event Counting Using Visual Basic

```
'************************************
' Use this procedure for event counting
'************************************

Function StartEventCount (dl As DriverLINXSR, ByVal LogicalDevice As
Integer, ByVal LogicalChannel As Integer, ByVal source As Integer,
ByVal gate As Integer, ByVal clkOut As Integer, ByVal continuous As
Integer) As Integer
  ' Set up Service Request to perform task
  With dl
    .Req_device = LogicalDevice
    .Req_subsystem = DL_CT
    .Req_mode = DL_POLLED
    .Req_op = DL_START
    .Evt_Tim_type = DL_RATEEVENT
    .Evt_Tim_rateChannel = LogicalChannel
    .Evt_Tim_rateMode = DL_COUNT ' or DL_COUNT32 or DL_COUNT64
    .Evt_Tim_rateClock = source
    .Evt_Tim_rateGate = gate
    .Evt_Tim_ratePeriod = 0
    .Evt_Tim_rateOnCount = 0
    If continuous Then
      .Evt_Tim_ratePulses = 0
    Else
      .Evt_Tim_ratePulses = 1
    End If
    .Evt_Tim_rateOutput = clkOut
    ' Other events, buffers, channels unneeded
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 0
    .Sel_chan_N = 0
    .Refresh
    StartEventCount = .Res_result
  End With
End Function
```

Frequency Measurement

DriverLINX can measure the time-averaged frequency of an unknown frequency source connected to the **Clock** input. Frequency measurement requires two or more counter/timers configured as gating and measurement counters.

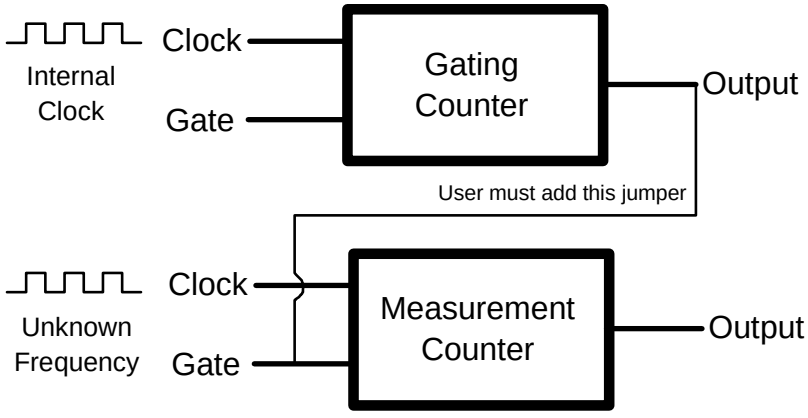


Figure 3 Frequency Measurement

The measurement counter counts the unknown frequency at its **Clock** input for a time interval defined by the gating counter. DriverLINX clocks the gating counter

from an internal crystal reference oscillator to produce a precise counting duration. Applications can calculate the unknown input frequency as

$$frequency = \frac{measurementCount}{gatingCount \times clockPeriod}$$

where *measurementCount* is the counter value DriverLINX reads from the measurement counter, *gatingCount* is the counter value the application specifies for the measurement interval in the Service Request, and *clockPeriod* is the duration of the reference oscillator's period. See "Converting Between Counts and Time" on page 58 for how to convert a count to seconds.

It is the application's responsibility to select the gating interval.

The accuracy of the measurement is a function of the unknown input frequency and the gating interval. As the input frequency decreases, the gating interval should increase to preserve accuracy. To measure a 0.1 Hz signal, the gating interval should be approximately 3 minutes.

Usage Notes

Use of this function is highly dependent on hardware features. Some models cannot stop nor latch counts in this mode so the results may be invalidated by counter rollover. This means that, on such hardware, a STATUS operation is required to sample the measurement counter after the first gate pulse but before the next. Depending on the clock frequency and counter width, the valid sample window can be very short.

Starting a Frequency Counter

To start a software-polled frequency counter, set up the Service Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	POLLED	START

Set up the Events Group as follows:

Timing	Start	Stop
Rate	None or Command	None or Terminal Count

See "Specifying the Rate Event for Frequency Measurements" on page 87 for how to assign the properties of a Rate Event. DriverLINX does not need Start or Stop events for frequency measurements, but the application may optionally specify Command and Terminal Count for Start and Stop events, respectively. For a Service Request that does not specify buffers, None and Command are equivalent for a Start Event as are None and Terminal Count for a Stop Event.

Specifying the Rate Event for Frequency Measurements

Each Am9513 chip has five counter/timer channels. When advancing to the next higher channel, the hardware wraps around from the last to first channel.

The KPCI-3140 chip cannot wrap around from the last to first.

DriverLINX supports 16- and 32-bit frequency measurements using multiple counter/timer channels. DriverLINX uses one counter (on the Am9513) or two counters (on the KPCI-3140) for the gating counter and one or two counters for the measurement counter. When using multiple counter/timer channels, the application specifies the Logical Channel of the first gating counter in the Service Request and DriverLINX automatically uses consecutive counter/timer channels for the measurement counter(s). The user may attach the unknown input source to any **Clock** or **Gate** input that DriverLINX allows for the *Clock* property.

DriverLINX supports repetitive (*Pulses* property = 0) and non-repetitive (*Pulses* property = 1) frequency measurement with several gating options as shown in the following tables for 16- and 32-bit frequency measurement. Repetitive counters continually repeat the frequency measurement. Non-repetitive counters measure one input cycle and then stop measuring.

The user must install a jumper to perform frequency measurements. See "Hardware Setup for Frequency Measurement" on page 89.

To set up a frequency measurement, select the type of measurement from the following tables and program the *Rate Generator* properties in a Service Request as specified. The *OnCount* property specifies the gating interval while the *Period* property should be zero. Other unused or unspecified properties should be set to zero. Applications can set the Rate Generator's *Output* property to any value. See "Counter Output" on page 55.

Am9513

The Am9513 Mode column in the following tables refers to the Advanced Micro Devices' letter designation for the hardware modes that DriverLINX uses to implement the counter function. See "Am9513 Operating Modes" on page 117 for information about hardware modes.

16-bit Frequency Measurement	AM9513 Mode	Channel	Mode	Clock	Gate	Pulses
Repetitive measurement with no hardware gating	J, Q	N..N+1	FREQ	<source>	DISABLED	0
Non-repetitive measurement with no hardware gating	G, Q	N..N+1	FREQ	<source>	DISABLED	1
Repetitive measurement with edge triggering	L, Q	N..N+1	FREQ	<source>	EDGE	0
Non-repetitive measurement with edge triggering	I, Q	N..N+1	FREQ	<source>	EDGE	1

Table 22 Rate Event Properties for 16-bit Frequency Measurement

32-bit Frequency Measurement	Am9513 Mode	Channel	Mode	Clock	Gate	Pulses
Repetitive measurement with no hardware gating	G, E, D	N..N+2	FREQ32	<source>	DISABLED	0
Non-repetitive measurement with no hardware gating	G, E, D	N..N+2	FREQ32	<source>	DISABLED	1
Repetitive measurement with edge triggering	I, E, D	N..N+2	FREQ32	<source>	EDGE	0
Non-repetitive measurement with edge triggering	I, E, D	N..N+2	FREQ32	<source>	EDGE	1

Table 23 Rate Event Properties for 32-bit Frequency Measurement

KPCI-3140

The KPCI-3140 Mode column refers to the hardware modes that DriverLINX uses to implement the counter function. See “KPCI-3140 Operating Modes” on page 116 for information about hardware modes.

16-bit Frequency Measurement	KPCI-3140 Mode	Channel	Mode	Clock	Gate	Pulses
Non-repetitive measurement with no hardware gating	2, 1 2	N..N+2	FREQ	<source>	DISABLED	1
Non-repetitive measurement with level gating	2, 1 2	N..N+2	FREQ	<source>	level	1

Table 24 Rate Event Properties for 16-bit Frequency Measurement

32-bit Frequency Measurement	KPCI-3140 Mode	Channel	Mode	Clock	Gate	Pulses
Non-repetitive measurement with no hardware gating	2, 1 2, 2	N..N+3	FREQ32	<source>	DISABLED	1
Non-repetitive measurement with level gating	2, 1 2, 2	N..N+3	FREQ32	<source>	level	1

Table 25 Rate Event Properties for 32-bit Frequency Measurement

Hardware Setup for Frequency Measurement

For frequency measurement, the application specifies the Logical Channel, N, of the gating counter in the Service Request. The user attaches the unknown frequency signal to the terminal the application specifies in the Service Request *Clock* property. Depending on the counting Mode, the user optionally attaches a signal to the **Gate** input.

*Before performing a frequency measurement, the user must physically attach a connection between the **Output** terminal of the last gating counter, Logical Channel N, and the **Gate** terminal of the first measurement counter, Logical Channel N+m.*

Channel	Clock	Gate	Output
N (first gating counter)		see tables	
N+m (first measurement counter)	unknown source		
N+m+ n (last measurement counter)			any

When using multiple counter/timer channels, the application's Service Request specifies the first gating counter/timer, and DriverLINX then automatically uses consecutive counter/timer channels for next gating counter, if any, and the measurement counter(s).

Frequency Measurement Using C/C++

```
//*****************************************
// Use this procedure for frequency measurement
//*****************************************

UINT StartFrequencyMeasurement (LPServiceRequest pSR,
                                UINT LogicalDevice,
                                UINT LogicalChannel, CLOCKS source,
                                GATESTATUS gate, ULONG measure,
                                UINT clkOut,
                                BOOLEAN continuous)
{
  // Set up Service Request to perform task

  // First zero Service Request structure
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  // Then initialize structure size
  DL_SetServiceRequestSize(*pSR);

  // Set up Request Group of Service Request
  pSR->hWnd = GetSafeHwnd();
  pSR->device = LogicalDevice;
  pSR->subsystem = CT;
  pSR->mode = POLLED;
  pSR->operation = START;

  // Set up Timing Event
  pSR->timing.typeEvent = RATEEVENT;
  pSR->timing.u.rateEvent.channel = LogicalChannel;
  pSR->timing.u.rateEvent.mode = FREQ; // or FREQ32
  pSR->timing.u.rateEvent.clock = source;
  pSR->timing.u.rateEvent.gate = gate;
  pSR->timing.u.rateEvent.period = 0;
  pSR->timing.u.rateEvent.onCount = measure;
  pSR->timing.u.rateEvent.pulses = continuous ? 0 : 1;
  pSR->timing.u.rateEvent.pulses |= clkOut;

  // Call DriverLINX to perform Service Request
  return DriverLINX(pSR);
}
```

Frequency Measurement Using Visual Basic

```
'*****************************************
' Use this procedure for frequency measurement
'*****************************************

Function StartFrequencyMeasurement (dl As DriverLINXSR, ByVal
LogicalDevice As Integer, ByVal LogicalChannel As Integer, ByVal source
As Integer, ByVal gate As Integer, ByVal measure as Long, ByVal clkOut
As Integer, ByVal continuous As Integer) As Integer
  ' Set up Service Request to perform task
  With dl
    .Req_device = LogicalDevice
    .Req_subsystem = DL_CT
    .Req_mode = DL_POLLED
    .Req_op = DL_START
    .Evt_Tim_type = DL_RATEEVENT
    .Evt_Tim_rateChannel = LogicalChannel
    .Evt_Tim_rateMode = DL_FREQ ' or DL_FREQ32
    .Evt_Tim_rateClock = source
    .Evt_Tim_rateGate = gate
    .Evt_Tim_ratePeriod = 0
    .Evt_Tim_rateOnCount = measure
    If continuous Then
      .Evt_Tim_ratePulses = 0
    Else
      .Evt_Tim_ratePulses = 1
    End If
    .Evt_Tim_rateOutput = clkOut
    ' Other events, buffers, channels unneeded
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 0
    .Sel_chan_N = 0
    .Refresh
    StartFrequencyMeasurement = .Res_result
  End With
End Function
```

Interval Measurement

DriverLINX can measure the time interval between two consecutive pulses using two techniques. In one technique, DriverLINX measures the time delay between two pulses connected to different counters. In the other technique, DriverLINX measures the delay between two pulses attached to the input of one counter.

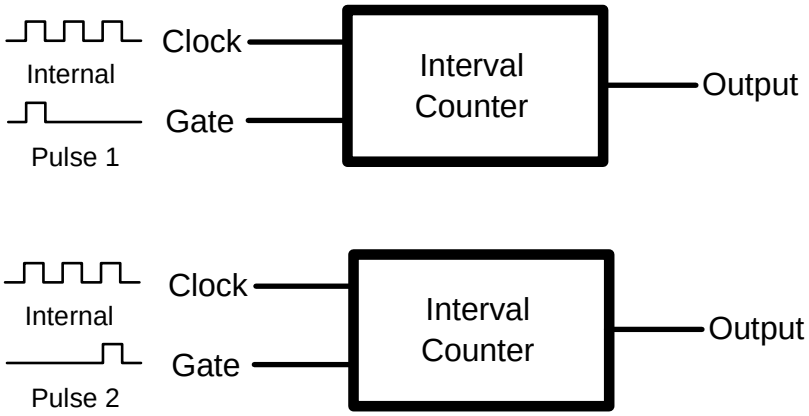


Figure 4 Interval Measurement on Two Channels

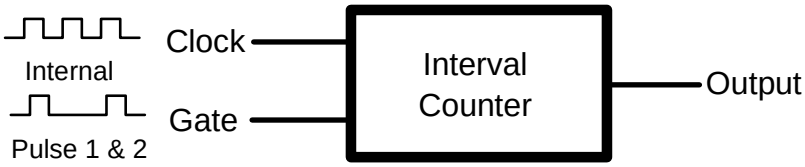


Figure 5 Interval Measurement on One Channel

Usage Notes

Use of this function is highly dependent on hardware features. Some hardware models support only single-input interval measurement, while other model support only dual-input interval measurement.

Also, some models cannot stop nor latch counts in this mode so subsequent pulses or counter rollover may invalidate the results. This means that, on such hardware, a STATUS operation is required to sample the counters after both pulses but before counter rollover. Depending on the clock frequency and pulse timing, the valid sample window can be very short.

Starting an Interval Counter

To start a software-polled interval counter, set up the Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	POLLED	START

Set up the Events Group as follows:

Timing	Start	Stop
Rate	None or Command	None or Terminal Count

See “Specifying the Rate Event for Interval Measurements” on page 93 for how to assign the properties of a Rate Event. DriverLINX does not need Start or Stop events for interval measurements, but the application may optionally specify Command and Terminal Count for Start and Stop events, respectively. For a Service Request that does not specify buffers, None and Command are equivalent for a Start Event as are None and Terminal Count for a Stop Event.

Specifying the Rate Event for Interval Measurements

DriverLINX supports 16-bit interval measurements using 1 or 2 counter/timer channels. When using a single input, DriverLINX measures the interval between two consecutive pulse edges connected to the **Gate** input. When dual inputs for interval measurements, DriverLINX measures the interval between pulse edges connected to the **Gate** inputs of each counter.

- To specify dual input interval measurements, the application specifies the first Logical Channel as the timing Logical Channel and specifies the second Logical Channel in the *Period* property of the Rate Event.
- To specify single input measurements, the application should set the *Period* property to the same value as the *Channel* property.

The Clock property must specify one of the internal clock sources. The internal clock period times 65536 determines the longest interval between two pulses that the hardware can measure.

Repetitive counters continually repeat the interval measurement. Non-repetitive counters measure one input pair and then stop counting.

To set up an interval measurement, program the *Rate Generator* properties in a Service Request as specified in the following table. Unused or unspecified properties should be set to zero. Applications can set the Rate Generator’s *Output* property to any value. See “Counter Output” on page 55.

Am9513

The Am9513 Mode column in the following tables refers to the Advanced Micro Devices’ letter designation for the hardware mode that DriverLINX uses to implement the counter function. See “Am9513 Operating Modes” on page 117 for information about hardware modes.

16-bit Interval Measurement	AM9513 Mode	Channel	Mode	Clock	Period	Pulses
Repetitive (single input) measurement	R	N	INTERVAL	<source>	N	0

Table 26 Rate Event Properties for 16-bit Interval Measurements

Hardware Setup for Interval Measurements

For interval measurements, the application specifies the Logical Channel(s) of the input counter(s) in the Service Request. The user attaches the unknown pulse signal(s) to the **Gate** inputs of the channel(s) the user specified. The application can program the counter/timer to measure the delay between the rising or falling edges of the pulses.

Interval Measurement Using C/C++

```
//*****************************************
// Use this procedure for interval measurements
//*****************************************

UINT StartIntervalMeasurement (LPServiceRequest pSR,
                               UINT LogicalDevice,
                               UINT LogicalChannel1,
                               UINT LogicalChannel2, CLOCKS source,
                               GATESTATUS gate,
                               UINT clkOut)
{
  // Set up Service Request to perform task

  // First zero Service Request structure
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  // Then initialize structure size
  DL_SetServiceRequestSize(*pSR);

  // Set up Request Group of Service Request
  pSR->hWnd = GetSafeHwnd();
  pSR->device = LogicalDevice;
  pSR->subsystem = CT;
  pSR->mode = POLLED;
  pSR->operation = START;

  // Set up Timing Event
  pSR->timing.typeEvent = RATEEVENT;
  pSR->timing.u.rateEvent.channel = LogicalChannel1;
  pSR->timing.u.rateEvent.mode = INTERVAL;
  pSR->timing.u.rateEvent.clock = source;
  pSR->timing.u.rateEvent.gate = gate;
  pSR->timing.u.rateEvent.period = LogicalChannel2;
  pSR->timing.u.rateEvent.onCount = 0;
  pSR->timing.u.rateEvent.pulses =
                        LogicalChannel1 == LogicalChannel2 ? 0 : 1;
  pSR->timing.u.rateEvent.pulses |= clkOut;

  // Call DriverLINX to perform Service Request
  return DriverLINX(pSR);
}
```

Interval Measurement Using Visual Basic

```
'*****************************************
' Use this procedure for interval measurements
'*****************************************

Function StartIntervalMeasurement (dl As DriverLINXSR, ByVal
LogicalDevice As Integer, ByVal LogicalChannel1 As Integer, ByVal
LogicalChannel2 As Integer, ByVal source As Integer, ByVal gate As
Integer, ByVal clkOut As Integer) As Integer
  ' Set up Service Request to perform task
  With dl
    .Req_device = LogicalDevice
    .Req_subsystem = DL_CT
    .Req_mode = DL_POLLED
    .Req_op = DL_START
    .Evt_Tim_type = DL_RATEEVENT
    .Evt_Tim_rateChannel = LogicalChannel1
    .Evt_Tim_rateMode = DL_INTERVAL
    .Evt_Tim_rateClock = source
    .Evt_Tim_rateGate = gate
    .Evt_Tim_ratePeriod = LogicalChannel2
    .Evt_Tim_rateOnCount = 0
    If LogicalChannel1 = LogicalChannel2 Then
      .Evt_Tim_ratePulses = 0
    Else
      .Evt_Tim_ratePulses = 1
    End If
    .Evt_Tim_rateOutput = clkOut
    ' Other events, buffers, channels unneeded
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 0
    .Sel_chan_N = 0
    .Refresh
    StartIntervalMeasurement = .Res_result
  End With
End Function
```

Period and Pulse Width Measurement

DriverLINX can measure the period, or duration, of a single cycle of an unknown input.

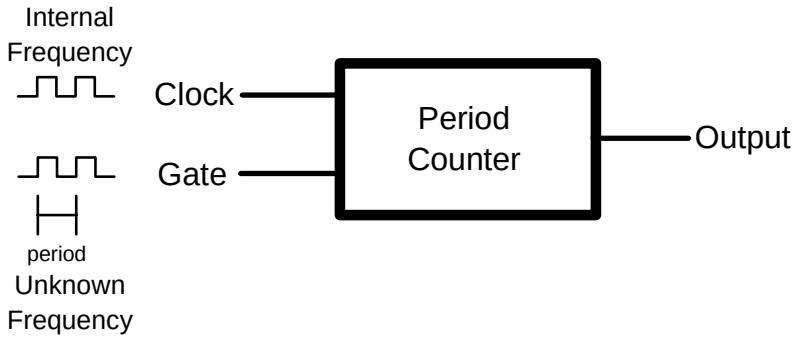


Figure 6 Period Measurement

DriverLINX can measure the duration of the positive or negative half-cycle of an input.

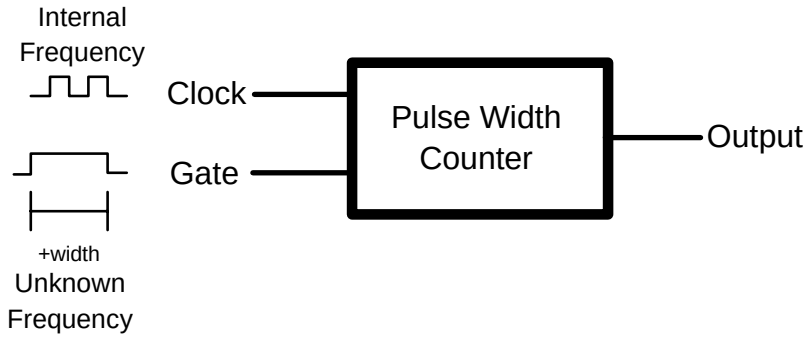


Figure 7 Pulse Width Measurement

Starting an Period or Pulse Width Measurement

To start a software-polled period or pulse width measurement, set up the Service Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	POLLED	START

Set up the Events Group as follows:

Timing	Start	Stop
Rate	None or Command	None or Terminal Count

See “Specifying the Rate Event for Period and Pulse Width Measurements” on page 97 for how to assign the properties of a Rate Event. DriverLINX does not need Start or Stop events for period and pulse width measurements, but the application may optionally specify Command and Terminal Count for Start and Stop events, respectively. For a Start Event, None and Command are equivalent for a Start Event as are None and Terminal Count for a Stop Event.

Specifying the Rate Event for Period and Pulse Width Measurements

DriverLINX supports period and pulse width measurements using one counter/timer channel.

- To measure a period, DriverLINX times the interval between two rising or falling edges at the **Gate** input. To specify a period measurement, set the *Gate* property of the Rate Event to one of the edge trigger values.
- To measure a pulse width, DriverLINX times the duration of the positive or negative half-cycle of the signal at the **Gate** input. To specify a pulse width measurement, set the *Gate* property of the Rate Event to one of the level gating values.

The Clock property must specify one of the internal clock sources. The internal clock period times maximum counter value determines the longest period or pulse width that the hardware can measure.

Repetitive counters continually repeat the interval measurement.

To set up a period or pulse width measurement, program the *Rate Generator* properties in a Service Request as specified in the following table. Unused or unspecified properties should be set to zero. Applications can set the Rate Generator’s *Output* property to any value. See “Counter Output” on page 55.

Am9513

The Am9513 Mode column in the following tables refers to the Advanced Micro Devices’ letter designation for the hardware mode that DriverLINX uses to implement the counter function. See “Am9513 Operating Modes” on page 117 for information about hardware modes.

16-bit Period Measurement	AM9513 Mode	Channel	Mode	Clock	Gate	Pulses
Repetitive measurement with edge triggering	R	N	PULSEWD	INTERNAL	EDGE	0

Table 27 Rate Event Properties for 16-bit Period Measurements

16-bit Pulse Width Measurement	AM9513 Mode	Channel	Mode	Clock	Gate	Pulses
Repetitive measurement with level gating	Q	N	PULSEWD	INTERNAL	LEVEL	0

Table 28 Rate Event Properties for 16-bit Pulse Width Measurements

KPCI-3140

The KPCI-3140 Mode column refers to the hardware mode that DriverLINX uses to implement the counter function. See “KPCI-3140 Operating Modes” on page 116 for information about hardware modes.

16-bit Pulse Width Measurement	KPCI-3140 Mode	Channel	Mode	Clock	Gate	Pulses
Repetitive measurement with level gating	2	N	PULSEWD	INTERNAL	LEVEL	0

Table 29 Rate Event Properties for 16-bit Pulse Width Measurement

Hardware Setup for Period and Pulse Width Measurements

For period and pulse width measurements, the application specifies the Logical Channel of the measurement counter in the Service Request. The user should attach the unknown signal to the **Gate** input of the channel specified in the Service Request. The application can program the counter/timer to measure the delay between the rising or falling edges of the signal or to measure the duration of the positive or negative half cycle.

Period or Pulse Width Measurements Using C/C++

```
//*********************************************************
// Use this procedure for period and pulse width measurements
//*********************************************************

UINT StartPeriodPulseWidthMeasurement (LPServiceRequest pSR,
                                       UINT LogicalDevice,
                                       UINT LogicalChannel,
                                       CLOCKS source,
                                       GATESTATUS gate,
                                       UINT clkOut)
{
  // Set up Service Request to perform task

  // First zero Service Request structure
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  // Then initialize structure size
  DL_SetServiceRequestSize(*pSR);

  // Set up Request Group of Service Request
  pSR->hWnd = GetSafeHwnd();
  pSR->device = LogicalDevice;
  pSR->subsystem = CT;
  pSR->mode = POLLED;
  pSR->operation = START;

  // Set up Timing Event
  pSR->timing.typeEvent = RATEEVENT;
  pSR->timing.u.rateEvent.channel = LogicalChannel;
  pSR->timing.u.rateEvent.mode = PULSEWD;
  pSR->timing.u.rateEvent.clock = source;
  pSR->timing.u.rateEvent.gate = gate;
  pSR->timing.u.rateEvent.period = 0;
  pSR->timing.u.rateEvent.onCount = 0;
  pSR->timing.u.rateEvent.pulses = 0;
  pSR->timing.u.rateEvent.pulses |= clkOut;

  // Call DriverLINX to perform Service Request
  return DriverLINX(pSR);
}
```

Period or Pulse Width Measurement Using Visual Basic

```
'*********************************************************
' Use this procedure for period or pulse width measurements
'*********************************************************
Function StartPeriodPulseWidthMeasurement (dl As DriverLINXSR, ByVal
LogicalDevice As Integer, ByVal LogicalChannel As Integer, ByVal source
As Integer, ByVal gate As Integer, ByVal clkOut As Integer)As Integer
  ' Set up Service Request to perform task
  With dl
    .Req_device = LogicalDevice
    .Req_subsystem = DL_CT
    .Req_mode = DL_POLLED
    .Req_op = DL_START
    .Evt_Tim_type = DL_RATEEVENT
    .Evt_Tim_rateChannel = LogicalChannel
    .Evt_Tim_rateMode = DL_PULSEWD
    .Evt_Tim_rateClock = source
    .Evt_Tim_rateGate = gate
    .Evt_Tim_ratePeriod = 0
    .Evt_Tim_rateOnCount = 0
    .Evt_Tim_ratePulses = 0
    .Evt_Tim_rateOutput = clkOut
    ' Other events, buffers, channels unneeded
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 0
    .Sel_chan_N = 0
    .Refresh
    StartPeriodPulseWidthMeasurement = .Res_result
  End With
End Function
```

Pulse and Strobe Generation

DriverLINX can generate a variety of single pulses, delayed pulses, and strobes or one-shots. DriverLINX uses two parameters to characterize delayed pulses—delay time and pulse duration. DriverLINX uses just one parameter, delay time, to characterize strobes or one-shots.

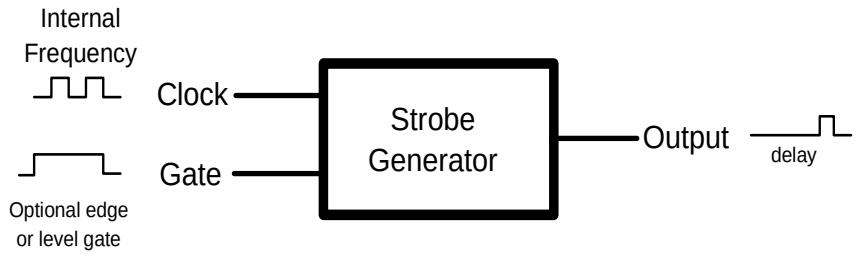


Figure 8 Strobe or One-shot Generation

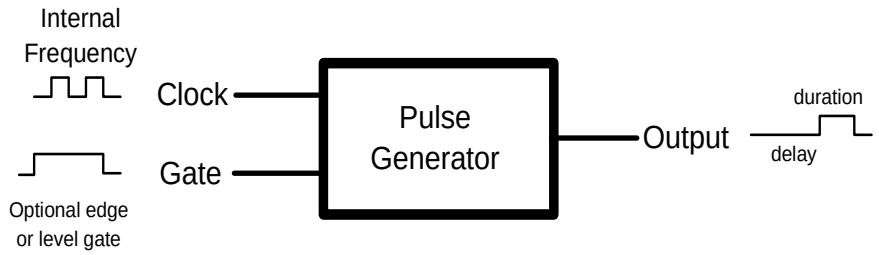


Figure 9 Pulse Generation

Starting Pulse and Strobe Generation

To start a software-polled pulse or strobe output, set up the Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	POLLED	START

Set up the Events Group as follows:

Timing	Start	Stop
Rate	None or Command	None or Terminal Count

See “Specifying the Rate Event for Pulses and Strobes” on page 102 for how to assign the properties of a Rate Event. DriverLINX does not need Start or Stop events for pulses and strobes, but the application may optionally specify Command and Terminal Count for Start and Stop events, respectively. For a Start Event, None and

Command are equivalent for a Start Event as are None and Terminal Count for a Stop Event.

Specifying the Rate Event for Pulses and Strobes

DriverLINX supports 16-bit pulse and strobe generation using one counter/timer channel. For strobe or one-shot outputs, the application specifies the delay preceding the strobe pulse using the *Period* property of the Rate Event. For delayed pulses, the application specifies the delay preceding the pulse using the *Period* property and the duration of the pulse using the *OnCount* property of the Rate Event.

Generally, the *Clock* property should specify one of the internal clock sources, but you may use any allowed source for the **Clock** input. The clock period times 65536 determines the longest delay and pulse width that the hardware can generate.

Repetitive counters support hardware retriggering. Non-repetitive generate a single pulse and stop.

To set up strobes and pulses, program the *Rate Generator* properties in a Service Request as specified in the following table. Unused or unspecified properties should be set to zero. Applications can set the Rate Generator's *Output* property to any value. See "Counter Output" on page 55. By default, strobes generate an active high pulse for 1 clock period after the delay while pulses toggle from low to high after the delay.

AM9513

The Am9513 Mode column in the following tables refers to the Advanced Micro Devices' letter designation for the hardware mode that DriverLINX uses to implement the counter function. See "Am9513 Operating Modes" on page 117 for information about hardware modes.

16-bit Strobes	AM9513 Mode	Mode	Period	OnCount	Gate	Pulses
Software-triggered strobe with no hardware gating	A	ONESHOT	delay	0	DISABLED	1
Software-triggered strobe with level gating	B	ONESHOT	delay	0	LEVEL	1
Hardware-triggered Strobe	C	ONESHOT	delay	0	EDGE	1
Non-retriggerable one-shot	F	ONESHOT	delay	0	EDGE	0
Software-triggered strobe with level gating and hardware retriggering	N	RETRIG ONESHOT	delay	0	LEVEL	1
Software-triggered strobe with edge gating	O	RETRIG ONESHOT	delay	0	EDGE	1

16-bit Strobes	AM9513 Mode	Mode	Period	OnCount	Gate	Pulses
and hardware retriggering						
Retriggerable one-shot	R	RETRIG ONESHOT	delay	0	EDGE	0

Table 30 Rate Event Properties for Strobes

16-bit Pulses	AM9513 Mode	Mode	Period	OnCount	Gate	Pulses
Software-triggered delayed pulse one-shot	G	PULSEGEN	delay	duration	DISABLED	1
Software-triggered delayed pulse one-shot with hardware gating	H	PULSEGEN	delay	duration	LEVEL	1
Hardware-triggered delayed pulse strobe	I	PULSEGEN	delay	duration	EDGE	1
Hardware-triggered delayed pulse one-shot	L	PULSEGEN	delay	duration	EDGE	0
Delayed pulse one-shot with level-selected reloading	S	FSKGEN	high delay	low delay	DISABLED	1

Table 31 Rate Event Properties for Pulses

KPCI-3140

The KPCI-3140 Mode column refers to the hardware mode that DriverLINX uses to implement the counter function. See “KPCI-3140 Operating Modes” on page 116 for information about hardware modes.

16-bit Strobes	KPCI-3140 Mode	Mode	Period	OnCount	Gate	Pulses
Software-triggered strobe with no hardware gating	0	ONESHOT	delay	0	DISABLED	1
Hardware-triggered Strobe	0	ONESHOT	delay	0	EDGE	1
Non-retriggerable one-shot	1	ONESHOT	delay	0	EDGE	0

Table 32 Rate Event Properties for Strobes

16-bit Pulses	KPCI-3140 Mode	Mode	Period	OnCount	Gate	Pulses
Software-triggered delayed pulse one-shot	0	PULSEGEN	delay	duration	DISABLED	1
Hardware-triggered delayed pulse strobe	0	PULSEGEN	delay	duration	EDGE	1
Hardware-triggered delayed pulse one-shot	1	PULSEGEN	delay	duration	EDGE	0

Table 33 Rate Event Properties for Pulses

Hardware Setup for Pulses and Strobes

For pulse and strobe generation, the application specifies the Logical Channel of the pulse counter in the Service Request. The user should attach any gating or triggering signals to the **Gate** input of the channel specified in the Service Request. The strobe or pulse output appears at the **Output** terminal of counter/timer.

Pulse and Strobe Generation Using C/C++

```
//************************************************
// Use this procedure to generate pulses and strobes
//************************************************

UINT StartPulseStrobe (LPServiceRequest pSR,
                       UINT LogicalDevice,
                       UINT LogicalChannel,
                       UINT delay,
                       UINT duration,
                       BOOLEAN retrig,
                       UINT pulses,
                       CLOCKS source,
                       GATESTATUS gate,
                       UINT clkOut)
{
  // Set up Service Request to perform task

  // First zero Service Request structure
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  // Then initialize structure size
  DL_SetServiceRequestSize(*pSR);

  // Set up Request Group of Service Request
  pSR->hWnd = GetSafeHwnd();
  pSR->device = LogicalDevice;
  pSR->subsystem = CT;
  pSR->mode = POLLED;
  pSR->operation = START;

  // Set up Timing Event
  pSR->timing.typeEvent = RATEEVENT;
  pSR->timing.u.rateEvent.channel = LogicalChannel;
  if (duration != 0)
    pSR->timing.u.rateEvent.mode = PULSEGEN;
  else
     pSR->timing.u.rateEvent.mode = retrig ? RETRIGONESHOT : ONESHOT;
  pSR->timing.u.rateEvent.clock = source;
  pSR->timing.u.rateEvent.gate = gate;
  pSR->timing.u.rateEvent.period = delay;
  pSR->timing.u.rateEvent.onCount = duration;
  pSR->timing.u.rateEvent.pulses = pulses;
  pSR->timing.u.rateEvent.pulses |= clkOut;

  // Call DriverLINX to perform Service Request
  return DriverLINX(pSR);
}
```

Pulse and Strobe Generation Using Visual Basic

```
'************************************************
' Use this procedure to generate pulses and strobes
'************************************************

Function StartPulseStrobe (dl As DriverLINXSR, ByVal LogicalDevice As
Integer, ByVal LogicalChannel As Integer, ByVal delay As Integer, ByVal
duration As Integer, ByVal retrig As Integer, ByVal pulses As Integer,
ByVal source As Integer, ByVal gate As Integer, ByVal clkOut As
Integer)As Integer
  ' Set up Service Request to perform task
  With dl
    .Req_device = LogicalDevice
    .Req_subsystem = DL_CT
    .Req_mode = DL_POLLED
    .Req_op = DL_START
    .Evt_Tim_type = DL_RATEEVENT
    .Evt_Tim_rateChannel = LogicalChannel
    If duration <> 0 Then
      .Evt_Tim_rateMode = DL_PULSEGEN
    Else
       If retrig <> 0 Then
         .Evt_Tim_rateMode = DL_RETRIGONESHOT
       Else
         .Evt_Tim_rateMode = DL_ONESHOT
       End If
    End If
    .Evt_Tim_rateClock = source
    .Evt_Tim_rateGate = gate
    .Evt_Tim_ratePeriod = delay
    .Evt_Tim_rateOnCount = duration
    .Evt_Tim_ratePulses = pulses
    .Evt_Tim_rateOutput = clkOut
    ' Other events, buffers, channels unneeded
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 0
    .Sel_chan_N = 0
    .Refresh
    StartPulseStrobe = .Res_result
  End With
End Function
```

Frequency Generation

DriverLINX can generate a variety of pulse trains, variable duty cycle waveforms, square waves, and frequency-shift keyed waveforms.

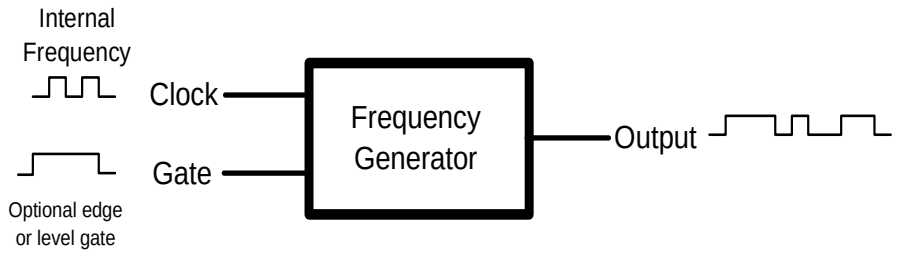


Figure 10 Frequency Generation

Starting Frequency Generation

To start frequency output, set up the Request Group as follows:

Device	Subsystem	Mode	Operation
<Logical Device>	CT	POLLED	START

Set up the Events Group as follows:

Timing	Start	Stop
Rate	None or Command	None or Terminal Count

See “Specifying the Rate Event for Frequency Generation” on page 107 for how to assign the properties of a Rate Event. DriverLINX does not need Start or Stop events for frequency generation, but the application may optionally specify Command and Terminal Count for Start and Stop events, respectively. For a Start Event, None or Command are equivalent, as are None or Terminal Count for a Stop Event.

Specifying the Rate Event for Frequency Generation

DriverLINX supports 16-bit frequency generation using one counter/timer channel.

The *Clock* property must specify one of the internal clock sources. The internal clock period times 65536 determines the longest period that the hardware can generate.

To set up a frequency generation, program the *Rate Generator* properties in a Service Request as specified in the following table. Unused or unspecified properties should be set to zero. Applications can set the Rate Generator’s *Output* property to any value. See “Counter Output” on page 55.

Am9513

The Am9513 Mode column in the following tables refers to the Advanced Micro Devices' letter designation for the hardware mode that DriverLINX uses to implement the counter function. See "Am9513 Operating Modes" on page 117 for information about hardware modes.

16-bit Frequency	AM9513 Mode	Mode	Period	OnCount	Gate	Pulses
Rate generator with no hardware gating	D	RATEGEN	period	0	DISABLED	0
Rate generator with level gating	E	RATEGEN	period	0	LEVEL	0
Rate generator with edge gating	X	RATEGEN	period	0	EDGE	0
Rate generator with synchronization	Q	RETRIG RATEGEN	period	0	LEVEL	0
Square wave generator with no hardware gating	D	SQWAVE	period	0	DISABLED	0
Square wave generator with level gating	E	SQWAVE	period	0	LEVEL	0
Square wave generator with edge gating	X	SQWAVE	period	0	EDGE	0
Square wave generator with synchronization	Q	RETRIG SQWAVE	period	0	LEVEL	0
Frequency divider with no hardware gating	D	DIVIDER	divisor	0	DISABLED	0
Frequency divider with level gating	E	DIVIDER	divisor	0	LEVEL	0
Frequency divider with edge gating	X	DIVIDER	divisor	0	EDGE	0

16-bit Frequency	AM9513 Mode	Mode	Period	OnCount	Gate	Pulses
Variable duty cycle rate generator with no hardware gating	J	VDCGEN	period	active high duration	DISABLED	0
Variable duty cycle rate generator with level gating	K	VDCGEN	delay	duration	LEVEL	0
Frequency-shift keying	V	FSKGEN	delay	duration	DISABLED	0

Table 34 Rate Event Properties for Frequency Generation

KPCI-3140

The KPCI-3140 Mode column refers to the hardware mode that DriverLINX uses to implement the counter function. See “KPCI-3140 Operating Modes” on page 116 for information about hardware modes.

16-bit Frequency	KPCI-3140 Mode	Mode	Period	OnCount	Gate	Pulses
Rate generator with no hardware gating	2	RATEGEN	period	0	DISABLED	0
Rate generator with level gating	2	RATEGEN	period	0	LEVEL	0
Square wave generator with no hardware gating	2	SQWAVE	period	0	DISABLED	0
Square wave generator with level gating	2	SQWAVE	period	0	LEVEL	0
Frequency divider with no hardware gating	2	DIVIDER	divisor	0	DISABLED	0
Frequency divider with level gating	2	DIVIDER	divisor	0	LEVEL	0

16-bit Frequency	KPCI-3140 Mode	Mode	Period	OnCount	Gate	Pulses
Variable duty cycle rate generator with no hardware gating	2	VDCGEN	period	active high duration	DISABLED	0
Variable duty cycle rate generator with level gating	2	VDCGEN	delay	duration	LEVEL	0

Table 35 Rate Event Properties for Frequency Generation

Hardware Setup for Frequency Generation

For frequency generation, the application specifies the Logical Channel of the frequency counter in the Service Request. The user should attach any gating or triggering signals to the **Gate** input of the channel specified in the Service Request. The frequency output appears at the **Output** terminal of counter/timer.

Frequency Generation Using C/C++

```
//*****************************************
// Use this procedure for frequency generation
//*****************************************

UINT StartFrequency (LPServiceRequest pSR,
                     UINT LogicalDevice,
                     UINT LogicalChannel,
                     GENERATORS mode,
                     UINT period,
                     UINT onCount,
                     CLOCKS source,
                     GATESTATUS gate,
                     UINT clkOut)
{
  // Set up Service Request to perform task

  // First zero Service Request structure
  memset(pSR, 0, sizeof(DL_SERVICEREQUEST));
  // Then initialize structure size
  DL_SetServiceRequestSize(*pSR);

  // Set up Request Group of Service Request
  pSR->hWnd = GetSafeHwnd();
  pSR->device = LogicalDevice;
  pSR->subsystem = CT;
  pSR->mode = POLLED;
  pSR->operation = START;

  // Set up Timing Event
  pSR->timing.typeEvent = RATEEVENT;
  pSR->timing.u.rateEvent.channel = LogicalChannel;
  pSR->timing.u.rateEvent.mode = mode;
  pSR->timing.u.rateEvent.clock = source;
  pSR->timing.u.rateEvent.gate = gate;
  pSR->timing.u.rateEvent.period = period;
  pSR->timing.u.rateEvent.onCount = onCount;
  pSR->timing.u.rateEvent.pulses = 0;
  pSR->timing.u.rateEvent.pulses |= clkOut;

  // Call DriverLINX to perform Service Request
  return DriverLINX(pSR);
}
```

Frequency Generation Using Visual Basic

```
'*************************************
' Use this procedure frequency generation
'*************************************
Function StartFrequency (dl As DriverLINXSR, ByVal LogicalDevice As
Integer, ByVal LogicalChannel As Integer, ByVal mode As Integer, ByVal
period As Integer, ByVal onCount As Integer, ByVal source As Integer,
ByVal gate As Integer, ByVal clkOut As Integer)As Integer
   ' Set up Service Request to perform task
  With dl
    .Req_device = LogicalDevice
    .Req_subsystem = DL_CT
    .Req_mode = DL_POLLED
    .Req_op = DL_START
    .Evt_Tim_type = DL_RATEEVENT
    .Evt_Tim_rateChannel = LogicalChannel
    .Evt_Tim_rateMode = mode
    .Evt_Tim_rateClock = source
    .Evt_Tim_rateGate = gate
    .Evt_Tim_ratePeriod = period
    .Evt_Tim_rateOnCount = onCount
    .Evt_Tim_ratePulses = 0
    .Evt_Tim_rateOutput = clkOut
    ' Other events, buffers, channels unneeded
    .Evt_Str_type = DL_NULLEVENT
    .Evt_Stp_type = DL_NULLEVENT
    .Sel_buf_N = 0
    .Sel_chan_N = 0
    .Refresh
    StartFrequency = .Res_result
  End With
End Function
```

Hardware Reference

8254 Operating Modes

This section describes the operating modes of the Intel 8254 Programmable Interval Timer and how to set up a DriverLINX Service Request to implement each of the 8254's modes. This information will help you to understand the 8254's hardware capabilities and to adopt legacy applications that use the 8254 to DriverLINX.

The 8254 is a simple chip. Each chip has three independently counter/timers that operate in one of six basic operating modes. Each counter/timer has only one single-polarity clock source, a single output mode (depending on the operating mode), and a single gate input mode (also, depending on the operating mode). Data-acquisition boards that use 8254 chips may expand the capabilities of the counter/timer with features such as off-chip clock source selection and gate modes, or reduce its capabilities by eliminating some external connections.

The following table shows how the 8254's hardware features and terminology map onto DriverLINX's counter/timer model.

Intel 8254	**DriverLINX**
Operating modes (0..5)	**Mode**, **Gate**, **Pulses** fields
Gating control	**Gate** field
Count source selection (off-chip)	**Clock** field
Count register	**Period** or (**Period** - **onCount**) value
Count once/repetitively	**Pulses** field
Binary/BCD counting	binary counting only

Intel and other 8254 manufacturers generally designate the 8254's six basic operating modes by the numbers 0 through 5. DriverLINX supports all these modes using combinations of the **Mode**, **Gate**, and **Pulses** fields. The following sections describe the 8254's basic modes using DriverLINX terminology.

Operating Mode Descriptions

Mode 0: Interrupt on Terminal Count

Mode 0 provides a software-triggered strobe with level gating. The application must issue a START (arm) command to the counter before it can begin counting. Once armed, the counter counts all **Clock** edges that occur while the **Gate** is high and disregards **Clock** edges that occur while the **Gate** is low. This feature permits the **Gate** to turn the count process on and off.

After receiving a START command, the counter sets its output low and counts to TC. Upon reaching TC, the counter sets its output high and automatically disarms itself inhibiting further counting. Counting resumes upon receipt of a STOP followed by a new START command.

Mode	Period	onCount	Pulses	Gate
ONESHOT	value	0	1	HiLevel

Mode 1:Hardware-retriggerable One-Shot

Mode 1 is similar to Mode 0 except that an armed counter does not begin counting until it detects a rising gate edge. The gate level does not modulate counting.

The application must START (arm) the counter before application of the triggering gate edge. A disarmed counter ignores gate edges. After receiving a START command, the counter sets its output high until the first rising gate edge. It then set its output low and counts to TC. Upon reaching TC, the counter sets its output high, reloads the **Period** value and disarms until the next rising gate edge.

All rising gate edges, including the first gate edge used to start the counter, retrigger the count process. On the first **Clock** edge after the retriggering gate edge, the counter loads the **Period** value. Counting resumes on the second **Clock** edge after a retrigger. Irrespective of the gate level, the counter counts all **Clock** edges after receiving the triggering gate edge until TC.

To initiate a new counting cycle, apply a STOP command followed by a new START command and a new gate edge.

Mode	Period	onCount	Pulses	Gate
RETRIGONESHOT	value	0	1	HiEdge

Mode 2: Rate Generator

Mode 2 produces a periodic output pulse with level gating. The application must issue a START (arm) command to the counter before it can begin counting. Once armed, the counter counts all **Clock** edges that occur while the **Gate** is high and disregards **Clock** edges that occur while the **Gate** is low. When the **Gate** rises, the counter resets the count and resumes counting. This feature permits the **Gate** to turn the count process on and off, and to synchronize the count with an external signal.

After receiving a START command, the counter sets its output high and counts to TC. Upon reaching TC, the counter sets its output low for one clock pulse and the

reloads the counter. Counting continues until the application sends a STOP command.

Mode	Period	onCount	Pulses	Gate
RATEGEN	value	0	0	HiLevel

Mode 3: Square Wave

Mode 3 is identical to Mode 2 except that the duty cycle of the output is 50% for even **Periods** and about 50% for odd **Periods.** The initial output level is high. The counter toggles the output at TC / 2 and again at TC. Counting continues until the application sends a STOP command.

Mode	Period	onCount	Pulses	Gate
SQWAVE	value	0	0	HiLevel

Mode 4: Software-triggered Strobe

Mode 4 is similar to Mode 0 except that the duty cycle and phase of the output. The output is initially high and goes low for one clock cycle at TC.

The application must issue a START (arm) command to the counter before it can begin counting. Once armed, the counter counts all **Clock** edges that occur while the **Gate** is high and disregards **Clock** edges that occur while the **Gate** is low. This feature permits the **Gate** to turn the count process on and off.

After receiving a START command, the counter sets its output high and counts to TC. Upon reaching TC, the counter sets its output low for one clock pulse. It then automatically disarms itself inhibiting further counting. Counting resumes upon receipt of a STOP followed by a new START command.

Mode	Period	onCount	Pulses	Gate
RETRIGONESHOT	value	0	1	HiLevel

Mode 5: Hardware-triggered Strobe

Mode 5 is identical to Mode 4 except that the **Gate** input triggers counting instead of modulating counting.

The application must arm the counter with a START command before the application of a rising gate edge; the counter ignores gate edges in the disarmed state. The counter starts counting on the first **Clock** edge after the rising gate edge and continues until TC. At TC, the counter reloads the **Period** value and automatically rearms itself. Counting resumes at the next rising gate edge.

Mode	Period	onCount	Pulses	Gate
ONESHOT	value	0	1	HiEdge

KPCI-3140 Operating Modes

This section describes the operating modes of the Keithley KPCI-3140 proprietary counter/timer chip and how to set up a DriverLINX Service Request to implement each of the KPCI-3140's modes. This information will help you to understand the KPCI-3140's hardware capabilities.

The KPCI-3140 counter/timer chip is a simple chip. Each chip has four 16-bit counter/timers available for user functions. It also has two 24-bit counter/timers but they can only be used for pacing. The user counter/timers can operate in one of three basic operating modes. The mode determines whether the gate is edge or level sensitive.

The following table shows how the KPCI-3140's hardware features and terminology map onto DriverLINX's counter/timer model.

KPCI-3140 CT Chip	DriverLINX
Operating modes (0..2)	**Mode**, **Pulses** fields
Gating control	**Gate** field
Count source selection	**Clock** field
Load register	**Period** field
Pulse register	**Period - onCount** field
Count once/repetitively	**Pulses** field

DriverLINX supports the chip's there operating modes using combinations of the **Mode**, **Gate**, and **Pulses** fields. The following sections describe the basic modes using DriverLINX terminology.

Operating Mode Descriptions

Mode 0: Non-retriggerable One-shot

In non-retriggerable one-shot mode, DriverLINX arms the counter at the start of the task. If a gate edge is specified, the counter waits for a rising or falling edge trigger on the external gate input, otherwise DriverLINX triggers the counter via software. When the trigger occurs, the counter begins incrementing. When the counter reaches the value specified by Period - onCount, it activates its output for at least one count. The output stays active until the counter reaches the terminal count specified in the Period field. The counter then deactivates its output and stops.

Mode 0 is identical to mode 1 except that mode 0 ignores all triggers after the first trigger.

Mode	Period	onCount	Pulses	Gate
PULSEGEN	delay	duration	1	edge
PULSEGEN	delay	duration	1	DISABLED
ONESHOT	period	0	1	edge
ONESHOT	period	0	1	DISABLED

Mode 1: Retriggerable One-shot

In retriggerable one-shot mode, DriverLINX arms the counter at the start of the task. If a gate edge is specified, the counter waits for a rising or falling edge trigger on the external gate input, otherwise DriverLINX triggers the counter via software. When the trigger occurs, the counter begins incrementing. When the counter reaches the value specified by Period - onCount, it activates its output for at least one count. The output stays active until the counter reaches the terminal count specified in the Period field. The counter then deactivates its output and stops. A trigger while the counter is stopped restarts the cycle.

Mode 0 is identical to mode 1 except that mode 0 ignores all triggers after the first trigger.

Mode	Period	onCount	Pulses	Gate
PULSEGEN	delay	duration	0	edge
PULSEGEN	delay	duration	0	DISABLED
ONESHOT	value	0	0	edge
ONESHOT	value	0	0	DISABLED

Mode 2: Continuous Increment

In continuous increment mode, DriverLINX arms and starts the counter. When the counter reaches the value specified by Period - onCount, it activates its output for at least one count. The output stays active until the counter reaches to the terminal count. The output stays active until the counter reaches the terminal count specified in the Period field. The counter then deactivates its output, reloads and continues counting. The counter pauses during counting when an enabled gate signal is not at the specified level.

Mode	Period	onCount	Pulses	Gate
VDCGEN	period	on count	0	level
RATEGEN	period	0	0	level
SQWAVE	period	0	0	level
DIVIDER	divisor	0	0	level
VDCGEN	period	on count	0	DISABLED
RATEGEN	period	0	0	DISABLED
SQWAVE	period	0	0	DISABLED
DIVIDER	divisor	0	0	DISABLED

Am9513 Operating Modes

This section describes the operating modes of the Am9513 System Timing Controller and how to set up a DriverLINX Service Request to implement each of the Am9513's modes. This information will help you to understand the Am9513's hardware capabilities and to adopt legacy applications that use the Am9513 to DriverLINX.

The Am9513 is a complex chip. Each Am9513 counter/timer supports about 12,160 parameter combinations. Users can select from 19 basic operating modes, 16 clock (source) inputs, 2 clock polarities, 2 counting types, 2 counting directions, and 5 output options. If you interconnect counter/timers, the number of possible combinations soars to about 2×10^{20}. Clearly some organization is needed.

The following table shows how the Am9513's hardware features and terminology map onto DriverLINX's counter/timer model.

Am9513	**DriverLINX**
Operating modes (A..X)	**Mode**, **Gate**, **Pulses** fields
Gating control	**Gate** field
Source edge	polarity of **Clock** field
Count source selection	**Clock** field
Output control	Output bits of **Pulses** field
Load register	**Period** or (**Period** - **onCount**) value
Hold register	**onCount** value or STATUS result
Counting direction	based on **Mode**
Count once/repetitively	**Pulses** field
Binary/BCD counting	binary counting only

Advanced Micro Devices and vendors of Am9513-based boards generally designate the Am9513's 19 basic operating modes by capital letters, A through X. DriverLINX supports all these modes using combinations of the **Mode**, **Gate**, and **Pulses** fields. The following sections describe the Am9513's basic modes using DriverLINX terminology.

Operating Mode Descriptions

Mode A: Software-Triggered Strobe with No Hardware Gating

Mode A is one of the simplest operating modes. The counter counts **Clock** edges when it receives a START (arm) command. On each TC, the counter reloads the **Period** value and automatically disarms itself. Counting resumes when the application issues a STOP followed by a new START command.

Mode	**Period**	**onCount**	**Pulses**	**Gate**
ONESHOT	value	0	1	DISABLED

Mode B: Software-Triggered Strobe with Level Gating

Mode B is identical to Mode A except that the counter only counts **Clock** edges when the programmed gate input is active. The application must arm the counter with a START command before counting can occur. Once armed, the counter counts all **Clock** edges that occur while the gate is active; the counter disregards those edges that occur while the gate is inactive. This feature permits the gate to turn the

count process on and off. On each TC, the counter reloads the **Period** value and automatically disarms itself, inhibiting further counting until the application issues a STOP followed by a new START command.

Mode	Period	onCount	Pulses	Gate
ONESHOT	value	0	1	level

Mode C: Hardware-triggered Strobe

Mode C is identical to Mode A except that an armed counter does not begin counting until it detects a gate edge at the **Gate** input.

The application must arm the counter with a START command before the application of a triggering gate edge; the counter ignores gate edges in the disarmed state. The counter starts counting on the first **Clock** edge after the triggering gate edge and continues until TC. At TC, the counter reloads the **Period** value and automatically disarms itself. Counting then remains inhibited until the application applies a STOP followed by a new START command and the counter then detects a new gate (in that order).

Note that after application of a triggering gate edge, the counter disregards the **Gate** input for the remainder of the count cycle. This process differs from that of Mode B where the **Gate** can be modulated throughout the count cycle to stop and start the counter.

Mode	Period	onCount	Pulses	Gate
ONESHOT	value	0	1	edge

Mode D: Rate Generator with No Hardware Gating

Applications typically use Mode D for frequency generation. In this mode the **Gate** input does not affect counter operation. Once STARTed, the counter counts to TC repetitively. On each TC the counter reloads the **Period** value; hence the **Period** value determines the time between TCs.

Mode	Period	onCount	Pulses	Gate
RATEGEN	value	0	0	DISABLED
SQWAVE	value	0	0	DISABLED

RATEGEN and SQWAVE both use Mode D, but the default output for RATEGEN is active high TC and for SQWAVE is TC toggled.

Mode E: Rate Generator with Level Gating

Mode E is identical to Mode D except that the counter only counts those **Clock** edges that occur while the **Gate** input is active. This feature allows hardware to enable and disable the counting process.

Mode	Period	onCount	Pulses	Gate
RATEGEN	value	0	0	level
SQWAVE	value	0	0	level

RATEGEN and SQWAVE both use Mode E, but the default output for RATEGEN is active high TC and for SQWAVE is TC toggled.

Mode F: Non-Retriggerable One-shot

Mode F provides a non-retriggerable, one-shot timing function. The application must START (arm) the counter before it can function. Application of a gate edge to the armed counter enables counting. When the counter reaches TC, it reloads itself from the **Period** value. The counter then stops counting awaiting a new gate edge.

Note that unlike Mode C, Mode F does not need a new START command after TC, but it does require a new gate edge. After application of a triggering gate edge, the counter disregards the **Gate** input until TC.

Mode	Period	onCount	Pulses	Gate
ONESHOT	value	0	0	edge

Mode G: Software-Triggered, Delayed Pulse One-shot

In Mode G, the **Gate** does not affect the counter's operation. Once STARTed (armed), the counter counts to TC twice and then automatically disarms itself. For most applications, the counter initially loads the **Period** value. Upon counting to the first TC, the counter will reload itself from the **onCount** value. Counting proceeds until the second TC when the counter reloads itself from the **Period** value and automatically disarms itself, inhibiting further counting. Applications can resume counting by issuing a STOP followed by a new START command.

Applications can generate a software-triggered, delayed pulse one-shot by specifying the TC toggled output mode. The **Period** value controls the delay from the START command until the output pulse starts. The **onCount** value controls the pulse duration.

Mode	Period	onCount	Pulses	Gate
PULSEGEN	value	value	1	DISABLED

Mode H: Software-Triggered, Delayed Pulse One-shot with Hardware Gating

Mode H is identical to Mode G except the **Gate** input qualifies which **Clock** edges the counter counts. The application must START (arm) the counter for counting to take place. Once armed, the counter counts all **Clock** edges that occur while the **Gate** is active and disregards those **Clock** edges that occur while the **Gate** is inactive. This permits the **Gate** to turn the count process on and off.

As with Mode G, the counter reloads using the **onCount** value on the first TC and reloads using the **Period** value and disarms on the second TC. Mode H allows the **Gate** to control the extension of both the initial output delay time (**Period**) and the pulse width (**onCount**).

Mode	Period	onCount	Pulses	Gate
PULSEGEN	value	value	1	level

Mode I: Hardware-triggered, Delayed Pulse Strobe

Mode I is identical to Mode G except that the counter does not begin counting until a STARTed (armed) counter detects a gate edge. The application must START the counter before application of the triggering gate edge. The counter disregards gate edges when disarmed. An armed counter starts counting on the first **Clock** edge after the triggering gate edge. Counting then proceeds in the same manner as in Mode G. After the second TC, the counter disarms itself. To restart counting, issue a STOP followed by a START command and a gate edge (in that order).

Note that after application of a triggering gate edge, the counter disregards the **Gate** input until the second TC. This sequence differs from Mode H where modulating the **Gate** throughout the count cycle stops and starts the counter.

Mode	Period	onCount	Pulses	Gate
PULSEGEN	value	value	1	edge

Mode J: Variable Duty Cycle Rate Generator with No Hardware Gating

Mode J finds its greatest use in frequency generation with variable duty cycle requirements. Once STARTed (armed), the counter counts continuously until it receives a STOP command. On the first TC, the counter will reload using the **onCount** value. Counting then proceeds until the second TC when the counter loads the (**Period** - **onCount**) value. Counting continues with the reload value alternating on each TC until the counter receives a STOP command.

Generate a variable duty cycle output by specifying one of the TC toggled output modes. The **Period** and **onCount** values then directly control the output duty cycle. For high resolution, use relatively high count values.

Mode	Period	onCount	Pulses	Gate
VDCGEN	value	value	0	disabled

Mode K: Variable Duty Cycle Rate Generator with Level Gating

Mode K is identical to Mode J except that the counter only counts **Clock** edges when the **Gate** is active. The application must START (arm) the counter for counting to occur. Once armed, the counter counts all **Clock** edges that occur while

the **Gate** is active and disregards those **Clock** edges that occur while the **Gate** is inactive. This feature permits the **Gate** to turn the count process on and off.

As during Mode J operation, the counter alternates the reload source on each TC, starting with the **onCount** value on the first TC after any START command. Use one of the TC toggled output modes to allow the **Gate** to modulate the duty cycle of the output waveform during both the high and low portions.

Mode	Period	onCount	Pulses	Gate
VDCGEN	value	value	0	level

Mode L: Hardware-Triggered Delayed Pulse One-shot

Mode L is similar to Mode J except that counting does not begin until an armed counter detects a gate edge. START (arm) the counter before applying the triggering gate edge. Disarmed counters ignore gate edges.

The counter starts counting **Clock** edges after the triggering gate edge, and counting proceeds until the second TC. Note that after the application of a triggering gate edge, the counter disregards the **Gate** input for the remainder of the count cycle. Because of this feature, Mode L differs from Mode K, which allows the **Gate** to modulate the count cycle to stop and start the counter.

On the first TC after application of the triggering gate edge, the counter reloads the **onCount** value. On the second TC, the counter reloads the **Period** value and stops counting until it detects a new gate edge. Note that unlike Mode K, the counter requires new gate edges after every second TC to continue counting.

Mode	Period	onCount	Pulses	Gate
PULSEGEN	value	value	0	edge

Mode N: Software-Triggered Strobe with Level Gating and Hardware Retriggering

Mode N provides a software-triggered strobe with level gating. The strobe is also hardware-retriggerable. The application must issue a START (arm) command to the counter before it can begin counting. Once armed, the counter counts all **Clock** edges that occur while the **Gate** is active and disregards **Clock** edges that occur while the **Gate** is inactive. This feature permits the **Gate** to turn the count process on and off.

After receiving a START command and an active gate, the counter counts to TC. Upon reaching TC, the counter reloads the **Period** value and automatically disarms itself inhibiting further counting. Counting resumes upon receipt of a STOP followed by a new START command.

All active-going gate edges issued to an armed counter cause a retrigger operation. Upon application of the gate edge, the counter saves the current count in the Hold register. On the first qualified **Clock** edge after application of the retriggering gate edge, the counter loads the **Period** value. Counting resumes on the second qualified **Clock** edge after the retriggering gate edge. Qualified **Clock** edges are active-going edges that occur while the gate is active.

Mode	Period	onCount	Pulses	Gate
RETRIGONESHOT	value	0	1	level

Mode O: Software-Triggered Strobe with Edge Gating and Hardware Retriggering

Mode O is similar to Mode N except that an armed counter does not begin counting until it detects an active-going gate edge. The gate level does not modulate counting.

The application must START (arm) the counter before application of the triggering gate edge. A disarmed counter ignores gate edges. Irrespective of the gate level, the counter counts all **Clock** edges after receiving the triggering gate edge until the first TC. On the first TC, the counter reloads the **Period** value and disarms. To initiate a new counting cycle, apply a STOP command followed by a new START command and a new gate edge.

Unlike operation in Modes C, F, I, and L, which disregard the **Gate** input after counting starts, all active-going gate edges, including the first gate edge used to start the counter, retrigger the count process. On each retriggering gate edge, the counter saves the current count in the Hold register. On the first **Clock** edge after the retriggering gate edge, the counter loads the **Period** value. Counting resumes on the second **Clock** edge after a retrigger.

Mode	Period	onCount	Pulses	Gate
RETRIGONESHOT	value	0	1	edge

Mode Q: Rate Generator with Synchronization (Event Counter with Auto-Read/Reset)

Mode Q provides a rate generator with synchronization or an event counter with auto-read/reset. The application must first issue a START (arm) command before counting can occur. Once armed, the counter counts all **Clock** edges that occur while the **Gate** is active and disregards those edges occurring while the **Gate** is inactive. This permits the **Gate** to turn the count process on and off.

After receiving a START command and an active gate, the counter counts to TC repetitively. On each TC, the counter reloads the **Period** value. At any time, an active-going gate edge at the **Gate** input retriggers the counter. The retriggering gate edge transfers the contents of the counter into the Hold register. The first qualified **Clock** edge after the retriggering gate edge transfers the **Period** value into the counter. Counting resumes on the second qualified **Clock** edge after the retriggering gate edge. Qualified **Clock** edges are active-going edges that occur while the **Gate** is active.

Mode	Period	onCount	Pulses	Gate
RETRIGRATEGEN	value	0	0	level
RETRIGSQWAVE	load	0	0	level

Mode R: Retriggerable One-shot

Mode R is similar to Mode Q except that Mode R uses edge gating rather than level gating. In other words, rather than use the gate level to qualify which **Clock** edges to count, Mode R uses gate edges to start the counting operation.

The application must START (arm) the counter before application of a triggering gate edge. A disarmed counter ignores applied gate edges. After application of a gate edge, an armed counter counts all **Clock** edges until TC irrespective of the gate level. On the first TC, the counter reloads the **Period** value and stops. The counter restarts counting after detecting a new gate edge. All applied gate edges, including the first used to trigger counting, initiate a retrigger operation. Upon application of a gate edge, the counter saves its current count in the Hold register. On the first **Clock** edge after the retriggering gate edge, the counter reloads the **Period** value. Counting resumes on the second **Clock** edge after the retriggering gate edge.

Mode	Period	onCount	Pulses	Gate
RETRIGONESHOT	value	0	0	edge

Mode S Delayed Pulse One-shot with Level-selected Reloading

In Mode S, the **Gate** input determines the reload **Clock** for armed or unarmed counters and for TC-initiated reloads. The **Gate** input in Mode S only selects the reload source; it does not start or modulate counting. When the **Gate** is low, the counter reloads the **Period** value; when the **Gate** is high, the counter reloads the **onCount** value. Once STARTed (armed), the counter counts to TC twice and then disarms itself. On each TC, the counter reloads the gate-selected source. Following the second TC, the counter requires a new START command to begin a new counting cycle.

Mode	Period	onCount	Pulses	Gate
FSKGEN	value	value	1	DISABLED

Mode V: Frequency-shift Keying

Mode V provides frequency-shift keying modulation capability. Gate operation in this mode is identical to that of Mode S. If the **Gate** is low, CONFIGURE or START commands or a TC-induced reload transfers the **Period** value to the counter. If the **Gate** is high, reloads occur from the **onCount** value. The polarity of the **Gate** selects only the reload source; it does not start or modulate counting.

Once armed, the counter counts repetitively to TC. On each TC, the **Gate** polarity selects the counter reload source. Counting continues in this manner until the application issues a STOP command. To obtain frequency-shift keying, specify the TC toggled output mode. Modulating the **Gate** input switches the output frequencies.

Mode	Period	onCount	Pulses	Gate
FSKGEN	value	value	0	DISABLED

Mode X: Hardware Save

Mode X provides a hardware sampling of the counter contents without interrupting the count. A START command arms the counter. Once armed, a gate edge starts the counting operation. Disarmed counters ignore gate edges. After application of the triggering gate edge, the counter counts all qualified **Clock** edges until the first TC irrespective of the gate level. Gate edges applied during the counting sequence store the current count in the Hold register, but they do not interrupt the counting sequence. On each TC, the counter reloads the **Period** value and stops. Subsequent counting requires a new triggering gate edge. Counting resumes on the first **Clock** edge following the triggering gate edge.

Mode	Period	onCount	Pulses	Gate
RATEGEN	value	0	0	edge
SQWAVE	value	0	0	edge

Glossary of Terms

ActiveX

Component software object using Microsoft's Component Object Model specification for 16- and 32-bit controls. ActiveX controls were formerly called OCX controls.

API

Application Programming Interface—the properties and methods used to communicate with a software service.

COM

Component Object Model is a specification of a binary standard for reusable software objects.

DMA

Direct Memory Access provides a direct device to memory hardware channel that does not require software overhead to transfer acquired data.

Kernel Mode

The privileged mode in which the operating system runs system software such as device drivers. Kernel mode software has complete access to memory and hardware resources.

Logical Channel

A DriverLINX-assigned number for a data channel of a Logical Subsystem.

Logical Device

A user-assigned number that a DriverLINX driver uses to designate an installed hardware device.

Logical Device Descriptor

A DriverLINX data structure that contains hardware specifications for a Logical Device.

Logical Subsystem

A set of related hardware resources on a data-acquisition device. DriverLINX abstractly characterizes all data-acquisition devices as consisting of seven possible subsystems—device, analog input, analog output, digital input, digital output, and counter/timer.

nibble

A nibble is 4 bits or ½ byte.

OCX

OLE Custom Controls are now called ActiveX custom controls.

OLE

Object Linking and Embedding is an older term for Microsoft's ActiveX technology.

Service Request

A DriverLINX data structure that completely specifies the parameters for all data-acquisition tasks.

TC

“Terminal Count” The Am9513 defines TC as that period of time when the counter contents would have been zero if the internal counter circuitry had not transferred an external value into the counter.

User Mode

The mode in which the operating system runs user applications. User mode software has restricted access to memory, other processes, and hardware.

VBX

Component software object using the 16-bit Visual Basic Custom Control specification. Many 16-bit C/C++ compilers and Delphi 1.0 also support VBX controls.

Index

E

F

G

H

I

K

L

M

N

O

P

R

W