# Data Acquisition Toolbox Quick Reference Guide

## Getting Started

If you have a sound card installed, you can run the following code, which collects one second of data.

```
ai = analoginput('winsound');
addchannel(ai,1);
set(ai,'SampleRate',11025)
set(ai,'SamplesPerTrigger',11025)
start(ai)
data = getdata(ai);
plot(data)
delete(ai)
clear ai
```

To list all the toolbox functions and demos, type

```
help daq
```

To display the command line help for a function, type

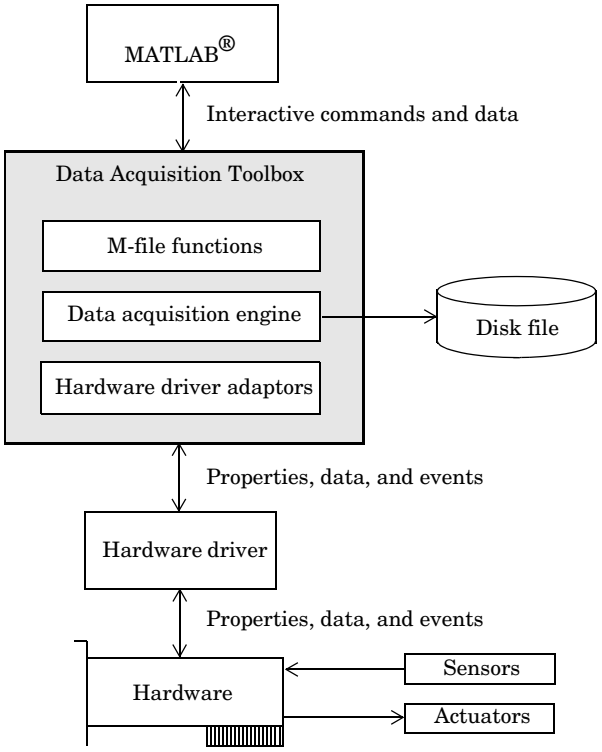
```
daqhelp function_name
```

## Toolbox Components

The Data Acquisition Toolbox consists of the three components listed below.

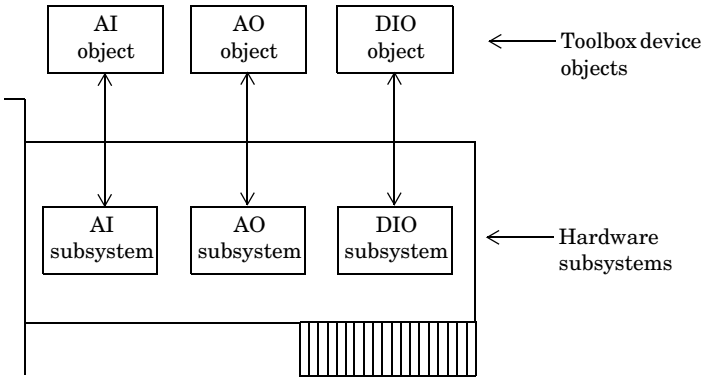
| Component | Purpose |
|---|---|
| M-files | Create device objects, acquire or output data, configure property values, and evaluate your acquisition status and resources. |
| Engine | Store device objects and their property values, control the storage of acquired or queued data, and control the synchronization of events. |
| Adaptors | Pass properties, data, and events between the hardware and the engine. |

These components are shown below.




## Device Objects

Device objects allow you to access specific hardware subsystems. The device objects supported by the toolbox include analog input (AI), analog output (AO), and digital I/O (DIO) objects.



## The Data Acquisition Session

A complete data acquisition session consists of five steps:

1. Creating a device object
2. Adding channels or lines to the device object
3. Configuring property values to control the behavior of your data acquisition application
4. Acquiring data (AI) or outputting data (AO)
5. Cleaning up

## Creating a Device Object

To create a device object, you must call the appropriate creation function (constructor). As shown below, creation functions are named for the device object they create.

| Subsystem Type | Creation Function |
|---|---|
| Analog input | `analoginput('adaptor',ID);` |
| Analog output | `analogoutput('adaptor',ID);` |
| Digital I/O | `digitalio('adaptor',ID);` |

`ID` is the hardware device identifier. This is an optional argument for sound cards with an `ID` of 0. `adaptor` is the name of the hardware driver adaptor. The supported adaptors are shown below.

| Hardware Vendor | Adaptor Name |
|---|---|
| Advantech | `advantech` |
| Agilent Technologies | `hpe1432` |
| Keithley Instruments | `keithley` |
| Measurement Computing | `mcc` |
| National Instruments | `nidaq` |
| Parallel port | `parallel` |
| Windows sound cards | `winsound` |

For example, to create the analog input object `ai` for a sound card:

```
ai = analoginput('winsound');
```

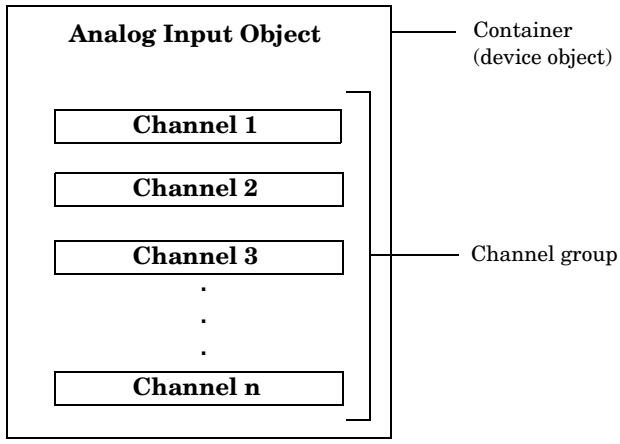
## Adding Channels or Lines

Before you can use a device object, you must add at least one channel or line to it. To add channels to a device object, you must use the `addchannel` function. For example, to add two channels to `ai`:

```
chans = addchannel(ai,1:2);
```

You can think of a device object as a channel or line container, the added channels as a channel group, and the added lines as a line group.

The relationship between an analog input object and the channels it contains is shown below.




For digital I/O objects, this diagram looks the same except that lines replace channels.

## Configuring Properties

You can control the behavior of your data acquisition application by configuring properties. The rules associated with configuring properties include

- Property names are not case sensitive.
- You can abbreviate property names.
- `set(ai)` returns all settable properties for `ai`, while `set(ai.Channel(index))` returns all settable properties for the specified channel.
- `get(ai)` returns the current property values for `ai`, while `get(ai.Channel(index))` returns the current property values for the specified channel.

### Property Types

Toolbox properties are divided into these two main types:

- Common properties that apply to every channel or line contained by a device object
- Channel/line properties that you can configure for individual channels or lines

Common and channel/line properties are divided into these two types:

- Base properties that apply to all supported hardware subsystems of a given type (AI, AO, DIO)
- Device-specific properties that apply to the specific hardware you are using

`set` and `get` display the base properties followed by the device-specific properties.

### Property Syntax

You can configure and return property values three ways: the `get` or `set` functions, dot notation, or named indexing.

The `get` and `set` syntax is similar to the Handle Graphics® `get` and `set` syntax.

```
out = get(ai,'SampleRate');
set(ai,'SampleRate',11025)
```

The dot notation has the following syntax:

```
out = ai.SampleRate;
ai.SampleRate = 11025;
```

Named indexing allows you to associate a descriptive name with a channel or line. For example, to associate the name `Chan1` with the first channel contained by `ai`:

```
set(ai.Channel(1),'ChannelName','Chan1');
out = ai.Chan1.UnitsRange;
ai.Chan1.UnitsRange = [0 10];
```

## Acquiring or Outputting Data

To acquire (AI) or output (AO) data, you must

**1** Start the device object.

**2** Log or send data.

**3** Stop the device object.

### Starting the Device Object

To start the device object, use the `start` function.

```
start(ai)
```

After the device object is started, the `Running` (AI) or `Sending` (AO) property is automatically set to `On`.

### Issuing a Trigger

To log data to the engine or a disk file (AI), or to output data from the engine (AO), a trigger must occur. The trigger types supported for all hardware are given below.

| Trigger Type | Description |
|---|---|
| `Immediate` | The trigger occurs just after you issue `start`. This is the default trigger type. |
| `Manual` | The trigger occurs after you manually issue the `trigger` function. |
| `Software` (AI only) | The trigger occurs when a signal satisfying the specified condition is detected. You must specify a channel as a trigger source. |

After the trigger occurs, the `Logging` (AI) or `Sending` (AO) property is automatically set to `On`.

### Stopping a Device Object

A device object stops when the requested data is acquired (AI) or output (AO), a run-time error occurs, or you issue the `stop` function.

```
stop(ai)
```

## Managing Data

### Previewing Data

While an AI object is running, you can preview acquired data with the `peekdata` function. For example, to preview 1000 samples for `ai`:

```
out = peekdata(ai,1000);
```

`peekdata` returns execution control immediately to MATLAB and does not extract data from the engine.

### Extracting Data

At any time after data is acquired by an AI object, you can extract it from the engine with the `getdata` function. For example, to extract 1000 samples for `ai`:

```
out = getdata(ai,1000);
```

`getdata` returns execution control to MATLAB only when all requested samples are returned.

### Outputting Data

To output data, you must first queue it in the engine with the `putdata` function. For example, to queue 1000 samples for the analog output object `ao`:

```
putdata(ao,[1:1000]')
```

Once data is queued, you can start the AO object.

## Reading and Writing Digital Values

Transferring digital values to and from a DIO subsystem is not clocked at a specific rate in the way that data is sampled by an analog input subsystem. Instead, values are either written directly to digital lines with `putvalue`, or read directly from digital lines with `getvalue`.

Additionally, DIO objects do not store data in the engine. Therefore, they do not require starting or triggering. For example, to write the value 23 to eight DIO lines:

```
dio = digitalio('nidaq',1);
addline(dio,0:7,'out');
data = 23;
putvalue(dio,data)
getvalue(dio)
```

## Events and Callbacks

An event occurs at a particular time after a condition is met. Unless an error occurs, all AI and AO data acquisition sessions contain a start, trigger, and stop event.

You can access event information with the `EventLog` property:

```
Events = ai.EventLog;
EventTypes = {Events.Type}
EventTypes =
    'Start'    'Trigger'    'Stop'
```

When an event occurs, you can execute an M-file *callback function*. You can select the callback function to be executed by specifying the name of the M-file as the value for the associated callback property.

For example, the following commands configure `ai` so that the M-file `daqcallback` is executed when a trigger, run-time error, or stop event occurs.

```
set(ai,'TriggerFcn',@daqcallback)
set(ai,'RuntimeErrorFcn',@daqcallback)
set(ai,'StopFcn',@daqcallback)
```

To see how you construct a callback function, type

```
type daqcallback
```

## Deleting and Clearing Device Objects

The `delete` function removes the specified device object from the engine but not from the MATLAB workspace.

```
delete(ai)
```

`ai` still exists in the MATLAB workspace, but is an invalid object since it is no longer associated with hardware. You should remove invalid device objects with the `clear` command.

```
clear ai
```

If you clear a valid device object, the object no longer exists in the workspace, but does exist in the engine. You can return device objects from the engine with the `daqfind` function.

```
out = daqfind;
ai = out(1);
```

## Saving and Loading Device Objects

You can save a device object to a MAT-file with the `save` command.

```
save ai
```

You can load a device object into the MATLAB workspace with the `load` command.

```
load ai
```

You can convert a device object to equivalent MATLAB code with the `obj2code` function.

```
obj2code(ai,'ai_save')
```

You can recreate the device object by running the M-file.

```
ai = ai_save
```

## Logging Information to Disk

For an AI object, you can log acquired data, events, device objects, and hardware information to a disk file using these properties.

```
set(ai,'LoggingMode','Disk&Memory')
set(ai,'LogFileName','data.daq')
set(ai,'LogToDiskMode','Index')
```

You can retrieve information from an existing log file using the `daqread` function. To retrieve all logged data:

```
data = daqread('data.daq');
```

To retrieve only object and hardware information:

```
daqinfo = daqread('data.daq','info');
```

## Getting Information and Help

You can obtain information or help about installed hardware, driver adaptors, device objects, functions, or properties using the functions shown below.

| Function | Description |
|---|---|
| `daqhelp` | Display help for device objects, constructors, adaptors, functions, and properties. |
| `daqhwinfo` | Display data acquisition hardware information. |
| `propinfo` | Return property characteristics for device objects, channels, or lines. |

PDF and HTML versions of the *Data Acquisition Toolbox User's Guide* are available through the Help browser.

# Functions

Toolbox functions and the device objects they are associated with are organized into the groups shown below. The supported device objects include analog input (AI), analog output (AO), and digital I/O (DIO).

| **Creating Device Objects** | | **AI** | **AO** | **DIO** |
|---|---|---|---|---|
| `analoginput` | Create an analog input object. | ✓ | | |
| `analogoutput` | Create an analog output object. | | ✓ | |
| `digitalio` | Create a digital I/O object. | | | ✓ |

| **Adding Channels and Lines** | | **AI** | **AO** | **DIO** |
|---|---|---|---|---|
| `addchannel` | Add hardware channels to an analog input or analog output object. | ✓ | ✓ | |
| `addline` | Add hardware lines to a digital I/O object. | | | ✓ |
| `addmuxchannel` | Add hardware channels when using a multiplexer board (National Instruments only). | ✓ | | |

| **Getting and Setting Properties** | | **AI** | **AO** | **DIO** |
|---|---|---|---|---|
| `get` | Return device object properties. | ✓ | ✓ | ✓ |
| `set` | Configure or display device object properties. | ✓ | ✓ | ✓ |
| `setverify` | Configure and return the specified property. | ✓ | ✓ | ✓ |

| **Executing the Object** | | **AI** | **AO** | **DIO** |
|---|---|---|---|---|
| `start` | Start a device object. | ✓ | ✓ | ✓ |
| `stop` | Stop a device object. | ✓ | ✓ | ✓ |
| `trigger` | Manually execute a trigger. | ✓ | ✓ | |
| `waittilstop` | Wait for the device object to stop running. | ✓ | ✓ | |

| **Working with Data** | | **AI** | **AO** | **DIO** |
|---|---|---|---|---|
| `flushdata` | Remove data from the data acquisition engine. | ✓ | | |
| `getdata` | Extract data, time, and event information from the data acquisition engine. | ✓ | | |
| `getsample` | Immediately acquire one sample. | ✓ | | |
| `getvalue` | Read values from lines. | | | ✓ |
| `peekdata` | Preview most recent acquired data. | ✓ | | |
| `putdata` | Queue data in the engine for eventual output. | | ✓ | |

| Working with Data | | AI | AO | DIO |
|---|---|---|---|---|
| putsample | Immediately output one sample. | | ✓ | |
| putvalue | Write values to lines. | | | ✓ |

| Getting Information and Help | | AI | AO | DIO |
|---|---|---|---|---|
| daqhelp | Display help for device objects, constructors, adaptors, functions, and properties. | ✓ | ✓ | ✓ |
| daqhwinfo | Display data acquisition hardware information. | ✓ | ✓ | ✓ |
| daqpropedit | Open the Data Acquisition Property Editor. | ✓ | ✓ | ✓ |
| propinfo | Return property characteristics for device objects, channels, or lines. | ✓ | ✓ | ✓ |

| General Purpose | | AI | AO | DIO |
|---|---|---|---|---|
| binvec2dec | Convert binary vector to decimal value. | | | ✓ |
| clear | Remove device objects from the MATLAB workspace. | ✓ | ✓ | ✓ |
| daqcallback | A callback function that displays event information for the specified event. | ✓ | ✓ | ✓ |
| daqfind | Return device objects, channels, or lines from the data acquisition engine to the MATLAB workspace. | ✓ | ✓ | ✓ |
| daqmem | Allocate or display memory resources. | ✓ | ✓ | |
| daqread | Read a Data Acquisition Toolbox (.daq) file. | ✓ | | |
| daqregister | Register or unregister a hardware driver adaptor. | ✓ | ✓ | ✓ |
| daqreset | Remove device objects and data acquisition DLLs from memory. | ✓ | ✓ | ✓ |
| dec2binvec | Convert decimal value to binary vector. | | | ✓ |
| delete | Remove device objects, channels, or lines from the data acquisition engine. | ✓ | ✓ | ✓ |
| disp | Display summary information for device objects, channels, or lines. | ✓ | ✓ | ✓ |
| ischannel | Check for channels. | ✓ | ✓ | ✓ |
| isdioline | Check for lines. | ✓ | ✓ | ✓ |
| isvalid | Determine whether device objects, channels, or lines are valid. | ✓ | ✓ | ✓ |
| length | Return the length of a device object, channel group, or line group. | ✓ | ✓ | ✓ |
| load | Load device objects, channels, or lines into the MATLAB workspace. | ✓ | ✓ | ✓ |
| makenames | Generate a list of descriptive channel or line names. | ✓ | ✓ | ✓ |
| muxchanidx | Return multiplexed scanned channel index (National Instruments only). | ✓ | | |
| obj2mfile | Convert device objects, channels, or lines to MATLAB code. | ✓ | ✓ | ✓ |
| save | Save device objects to a MAT-file. | ✓ | ✓ | ✓ |
| showdaqevents | Display event log information. | ✓ | ✓ | |
| size | Return the size of a device object, channel group, or line group. | ✓ | ✓ | ✓ |

# Analog Input Base Properties

Analog input base properties are divided into two main categories: common properties and channel properties. Common properties apply to every channel contained by the analog input object, while channel properties can be configured for individual channels.

## Common Properties

| **Analog Input Basic Setup Properties** | |
|---|---|
| `SamplesPerTrigger` | Specify the number of samples to acquire for each channel group member for each trigger that occurs. |
| `SampleRate` | Specify the per-channel rate at which analog data is converted to digital data. |
| `TriggerType` | Specify the type of trigger to execute. |

| **Analog Input Logging Properties** | |
|---|---|
| `LogFileName` | Specify the name of the disk file to which information is logged. |
| `Logging` | Indicate whether data is being logged to memory or to a disk file. |
| `LoggingMode` | Specify the destination for acquired data. |
| `LogToDiskMode` | Specify whether data, events, and hardware information are saved to one disk file or to multiple disk files. |

| **Analog Input Trigger Properties** | |
|---|---|
| `InitialTriggerTime` | Indicate the absolute time of the first trigger. |
| `ManualTriggerHwOn` | Specify that the hardware device starts when a manual trigger is issued. |
| `TriggerFcn` | Specify the M-file callback function to execute when a trigger occurs. |
| `TriggerChannel` | Specify the channel serving as a trigger source. |
| `TriggerCondition` | Specify the condition that must be satisfied before a trigger executes. |
| `TriggerConditionValue` | Specify one or more voltage values that must be satisfied before a trigger executes. |
| `TriggerDelay` | Specify the delay value for data logging. |
| `TriggerDelayUnits` | Specify the units in which trigger delay data is measured. |
| `TriggerRepeat` | Specify the number of additional times the trigger executes. |
| `TriggersExecuted` | Indicate the number of triggers that execute. |
| `TriggerType` | Specify the type of trigger to execute. |

| Analog Input Status Properties | |
|---|---|
| Logging | Indicate whether data is being logged to memory or to a disk file. |
| Running | Indicate whether the device object is running. |
| SamplesAcquired | Indicate the number of samples acquired per channel. |
| SamplesAvailable | Indicate the number of samples available per channel in the engine. |

| Analog Input Hardware Configuration Properties | |
|---|---|
| ChannelSkew | Specify the time between consecutive scanned hardware channels. |
| ChannelSkewMode | Specify how the channel skew is determined. |
| ClockSource | Specify the clock used to govern the hardware conversion rate. |
| InputType | Specify the analog input hardware channel configuration. |
| SampleRate | Specify the per-channel rate at which analog data is converted to digital data. |

| Analog Input Callback Properties | |
|---|---|
| DataMissedFcn | Specify the M-file callback function to execute when data is missed. |
| InputOverRangeFcn | Specify the M-file callback function to execute when acquired data exceeds the valid hardware range. |
| RuntimeErrorFcn | Specify the M-file callback function to execute when a run-time error occurs. |
| SamplesAcquiredFcn | Specify the M-file callback function to execute every time a predefined number of samples is acquired for each channel group member. |
| SamplesAcquiredFcnCount | Specify the number of samples to acquire for each channel group member before a samples acquired event is generated. |
| StartFcn | Specify the M-file callback function to execute just before the device object starts running. |
| StopFcn | Specify the M-file callback function to execute just after the device object stops running. |
| TimerFcn | Specify the M-file callback function to execute whenever a predefined period of time passes. |
| TimerPeriod | Specify the period of time between timer events. |
| TriggerFcn | Specify the M-file callback function to execute when a trigger occurs. |

| Analog Input General Purpose Properties | |
|---|---|
| BufferingConfig | Specify the per-channel allocated memory. |
| BufferingMode | Specify how memory is allocated. |
| Channel | Contain hardware channels added to the device object. |
| EventLog | Store information for specific events. |
| Name | Specify a descriptive name for the device object. |
| Tag | Specify a device object label. |
| Timeout | Specify an additional waiting time to extract data. |
| Type | Indicate the device object type. |
| UserData | Store data that you want to associate with a device object. |

## Channel Properties

| Analog Input Channel Properties | |
|---|---|
| ChannelName | Specify a descriptive channel name. |
| HwChannel | Specify the hardware channel ID. |
| Index | Indicate the MATLAB index of a hardware channel. |
| InputRange | Specify the range of the analog input subsystem. |
| NativeOffset | Indicate the offset to use when converting between the native data format and doubles. |
| NativeScaling | Indicate the scaling to use when converting between the native data format and doubles. |
| Parent | Indicate the parent (device object) of a channel. |
| SensorRange | Specify the range of data you expect from your sensor. |
| Type | Indicate a channel. |
| Units | Specify the engineering units label. |
| UnitsRange | Specify the range of data as engineering units. |

# Analog Output Base Properties

Analog output base properties are divided into two main categories: common properties and channel properties. Common properties apply to every channel contained by the analog output object, while channel properties can be configured for individual channels.

## Common Properties

| **Analog Output Basic Setup Properties** | |
|---|---|
| `SampleRate` | Specify the per-channel rate at which digital data is converted to analog data. |
| `TriggerType` | Specify the type of trigger to execute. |

| **Analog Output Trigger Properties** | |
|---|---|
| `InitialTriggerTime` | Indicate the absolute time of the first trigger. |
| `TriggerFcn` | Specify the M-file callback function to execute when a trigger occurs. |
| `TriggersExecuted` | Indicate the number of triggers that execute. |
| `TriggerType` | Specify the type of trigger to execute. |

| **Analog Output Status Properties** | |
|---|---|
| `Running` | Indicate whether the device object is running. |
| `SamplesAvailable` | Indicate the number of samples available per channel in the engine. |
| `SamplesOutput` | Indicate the number of samples output per channel from the engine. |
| `Sending` | Indicate whether data is being sent to the hardware device. |

| **Analog Output Hardware Configuration Properties** | |
|---|---|
| `ClockSource` | Specify the clock used to govern the hardware conversion rate. |
| `SampleRate` | Specify the per-channel rate at which digital data is converted to analog data. |

| **Analog Output Data Management Properties** | |
|---|---|
| `MaxSamplesQueued` | Indicate the maximum number of samples that can be queued in the engine. |
| `RepeatOutput` | Specify the number of additional times queued data is output. |
| `Timeout` | Specify an additional waiting time to queue data. |

| Analog Output Callback Properties | |
|---|---|
| RuntimeErrorFcn | Specify the M-file callback function to execute when a run-time error occurs. |
| SamplesOutputFcn | Specify the M-file callback function to execute every time a predefined number of samples is output for each channel group member. |
| SamplesOutputFcnCount | Specify the number of samples to output for each channel group member before a samples output event is generated. |
| StartFcn | Specify the M-file callback function to execute just before the device object starts running. |
| StopFcn | Specify the M-file callback function to execute just after the device object stops running. |
| TimerFcn | Specify the M-file callback function to execute whenever a predefined period of time passes. |
| TimerPeriod | Specify the period of time between timer events. |
| TriggerFcn | Specify the M-file callback function to execute when a trigger occurs. |

| Analog Output General Purpose Properties | |
|---|---|
| BufferingConfig | Specify the per-channel allocated memory. |
| BufferingMode | Specify how memory is allocated. |
| Channel | Contain hardware channels added to the device object. |
| EventLog | Store information for specific events. |
| Name | Specify a descriptive name for the device object. |
| OutOfDataMode | Specify how the value held by the analog output subsystem is determined. |
| Tag | Specify a device object label. |
| Type | Indicate the device object type. |
| UserData | Store data that you want to associate with a device object. |

## Channel Properties

| Analog Output Channel Properties | |
|---|---|
| `ChannelName` | Specify a descriptive channel name. |
| `DefaultChannel Value` | Specify the value held by the analog output subsystem. |
| `HwChannel` | Specify the hardware channel ID. |
| `Index` | Indicate the MATLAB index of a hardware channel. |
| `NativeOffset` | Indicate the offset to use when converting between the native data format and doubles. |
| `NativeScaling` | Indicate the scaling to use when converting between the native data format and doubles. |
| `OutputRange` | Specify the range of the analog output hardware subsystem. |
| `Parent` | Indicate the parent (device object) of a channel. |
| `Type` | Indicate a channel. |
| `Units` | Specify the engineering units label. |
| `UnitsRange` | Specify the range of data as engineering units. |

# Digital I/O Base Properties

Digital I/O base properties are divided into two main categories: common properties and line properties. Common properties apply to every line contained by the digital I/O object, while line properties can be configured for individual lines.

## Common Properties

| Digital I/O Common Properties | |
|---|---|
| `Line` | Contain hardware lines added to the device object. |
| `Name` | Specify a descriptive name for the device object. |
| `Running` | Indicate whether the device object is running. |
| `Tag` | Specify a device object label. |
| `TimerFcn` | Specify the M-file callback function to execute whenever a predefined period of time passes. |
| `TimerPeriod` | Specify the period of time between timer events. |
| `Type` | Indicate the device object type. |
| `UserData` | Store data that you want to associate with a device object. |

## Line Properties

| Digital I/O Line Properties | |
|---|---|
| `Direction` | Specify whether a line is used for input or output. |
| `HwLine` | Specify the hardware line ID. |
| `Index` | Indicate the MATLAB index of a hardware line. |
| `LineName` | Specify a descriptive line name. |
| `Parent` | Indicate the parent (device object) of a line. |
| `Port` | Specify the port ID. |
| `Type` | Indicate a line. |

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