IVI Instrument Driver Programming Guide (Visual C++ Edition)

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1- Overview

1-1 Recommendation Of IVI-COM Driver

Microsoft Visual C++(native version) is a suitable environment for using IVI-COM instrument drivers because it easily accesses COM components with Smart Pointer feature. Therefore this guidebook recommends using IVI-COM instrument drivers through the smart pointer feature.

Notes:

- This guidebook shows examples that use KikusuiPwx IVI instrument driver (KIKUSUI PWX series DC Power Supply). You can also use IVI drivers for other vendors and other models in the same manner.
- This guidebook describes how to create 32bit (x86) programs that run under Windows7 (x64), using Visual Studio 2010 (C++).

1-2 IVI Instrument Class Interface

When using an IVI instrument driver, there are two approaches – using specific interfaces and using class interfaces. The former is to use interfaces that are specific to an instrument driver and you can utilize the most of features of the instrument. The later is to utilize instrument class interfaces that are defined in the IVI specifications allowing to utilize interchangeability features, but instrument specific features are restricted.

Notes:

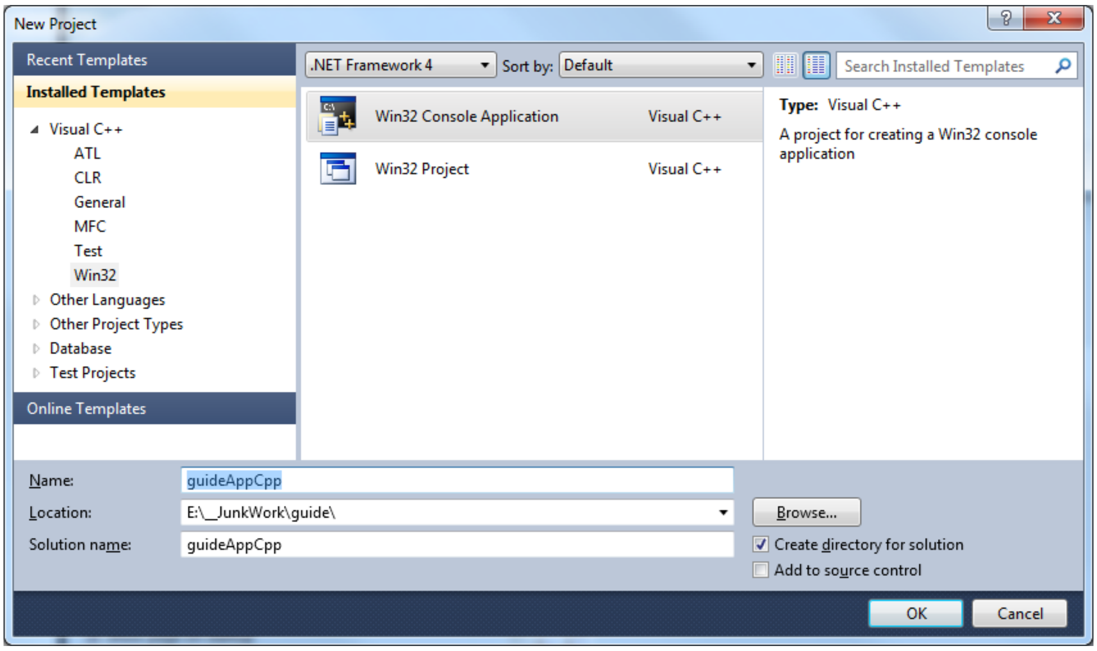
- The instrument class to which the instrument driver belongs is documented in Readme.txt for each of drivers. The Readme document can be viewed from Start button➔All Programs➔Kikusui➔KikusuiPwx menu.
- If the instrument driver does not belong to any instrument classes, you can't utilize class interfaces. This means that you cannot develop applications that utilize interchangeability features.

2- Example Using Specific Interface

Here we introduce an example using specific interfaces. By using specific interfaces, you can utilize the maximum feature (or model specific functions) provided by the driver but you have to spoil interchangeability.

2-1 Creating Application Project

To simplify explanation, this guidebook shows you an example of the simplest console application. After launching Visual Studio IDE, choose **File | New | Project** menu to bring up the **New Project** dialogue. Select **Win32** under **Visual C++** language from **Installed Templates**, then select **Win32 Console Application**. Also specify a project name (guideAppCpp in this example) then click OK. A new application project will be then created.



Name: guideAppCpp
Location: E:_JunkWork\guide\
Solution name: guideAppCpp
☑ Create directory for solution
☐ Add to source control

Figure 2-1 New Project Dialogue

2-2 Importing Type Libraries

What you should do first after creating a new project is, import type libraries for the IVI-COM instrument driver that you want to use. Open the **stdafx.h** file in your project, add the following **`#import`** lines after the existing #include lines.

```
#import "GlobMgr.dll" no_namespace named_guids
#import "IviDriverTypeLib.dll" no_namespace named_guids
#import "kipwx.dll" no_namespace named_guids
```

Notes:

- In the above description, we did not specify full-path to the DLL file names. But when compiler cannot find these files, you need explicitly specify full-path in the **`#import`** lines or, configure the directory conditions in Visual C++ environment settings so that the DLL can be implicitly imported.
- GlobMgr.dll (VISA Global Resource Manager DLL) is found in "C:/Program Files (x86)/IVI Foundation/VISA/VisaCom" directory.
- IVI driver DLLs are found in "C:/Program Files (x86)/IVI Foundation/IVI/Bin" directory.

2-3 Initializing COM Library

First, add **`CoInitializeEx`** and **`CoUninitialize`** calls in the **`_tmain`** function.

```
int _tmain(int argc, _TCHAR* argv[])
{
    HRESULT hr = CoInitializeEx( NULL, COINIT_APARTMENTTHREADED);

    // In this area, write codes that utilize COM

    CoUninitialize();
    return 0;
}
```

It is neccesary to call these functions from each thread that uses the COM library. Between COM functions are available between **`CoInitializeEx`** and **`CoUninitialize`** calls.

2-4 Creating Object and Initializing Session

Between **CoInitializeEx** and **CoUninitialize** calls, you write the following code fragments that opens a session for instrument driver object and close it. Here assume that an instrument (Kikusui PWX series DC supply) having IP address 192.168.1.5 connected with LAN interface.

```
try {
    IKikusuiPwxPtr spInstr;

    hr = spInstr.CreateInstance( CLSID_KikusuiPwx);

    spInstr->Initialize(
        L"TCPIP::192.168.1.5::INSTR",
        VARIANT_TRUE,
        VARIANT_TRUE,
        L"QueryInstrStatys=1");

    spInstr->Close();
}
catch(...) {
}
```

When creating a driver object, use **CreateInstance** method of Smart Pointer feature. Then you need pass **CLSID_KikusuiPwx** as a component GUID.

Every Visual C++ smart pointer has a type name that begins with interface type name (which begins with uppercase I) and ends with Ptr. (For the case of **IKikusuiPwx** interface, it is **IKikusuiPwxPtr** type.) When calling methods that manage itself such as component initialization, use the dot operator (.). Once the smart pointer is initialized, accesses to properies and methods of the COM interface use the pointer operator (->).

Just creating the object does not communicate with instrument, so furthermore invoke **Initialize** method and **Close** method.

Once the object is created with **CreateInstance**, its reference count is 1 at the point of time. When the scope of the variable **instr** has been lost (at the end of **try** block), the reference count is decremented. The object will be destroyed when the reference count becomes 0.

Notes:

- In the above example, mind that the **CoUninitialize** is invoked after the COM object gets destroyed. When using a smart pointer, you don't normally write object destruction code. Instead, it leaves to implicit destruction when the variable scope gets lost. In the above example, the code is written as the variable scope gets lost within the **try** block. If you wrote **CoUninitialize** call immediately after the **Close** call in the **try** block, the object destruction would postpone after **CoUninitialize** call causing the program to crash.
- In MFC-based projects, if the project is declared to use OLE or ActiveX, **CoInitializeEx/CoUninitialize** calls are already embedded in other parts allowing to omit explit calls.

Now let's talk about the parameters for the **Initialize** method. Every IVI-COM instrument driver has an **Initialize** method that is defined in the IVI specifications. This method has the following parameters.

Table 2-1 Params of Initialize Method

Parameter	Type	Description
`ResourceName`	`_bstr_t`	VISA resource name string. This is decided according to the I/O interface and/or address through which the instrument is connected. For example, a LAN-based instrument having IP address 192.168.1.5 will be `TCPIP::192.168.1.5::INSTR` (when VXI-11case).
`IdQuery`	`VARIANT_BOOL`	Specifying TRUE performs ID query to the instrument.
`Reset`	`VARIANT_BOOL`	Specifying TRUE resets the instrument settings.

`OptionString`	`_bstr_t`	Overrides the following settings instead of default:
		`RangeCheck`
		`Cache`
		`Simulate`
		`QueryInstrStatus`
		`RecordCoercions`
		`Interchange Check`
		Furthermore you can specify driver-specific options if the driver supports `DriverSetup` features.

`ResourceName` specifies a VISA resource. If **`IdQuery`** is TRUE, the driver queries the instrument identities using a query command such as **`"*IDN?"`**. If **`Reset`** is TRUE, the driver resets the instrument settings using a reset command such as **`"*RST"`**.

`OptionString` has two features. One is what configures IVI-defined behaviours such as **`RangeCheck`**, **`Cache`**, **`Simulate`**, **`QueryInstrStatus`**, **`RecordCoercions`**, and **`Interchange Check`**. Another one is what specifies **`DriverSetup`** that may be differently defined by each of instrument drivers. Because the **`OptionString`** is a string parameter, these settings must be written as like the following example:

```
QueryInstrStatus = TRUE , Cache = TRUE , DriverSetup=12345
```

(DriverSetup=12345 is only an imaginary parameter for explanation.)

Names and setting values for the features being set are case-insensitive. Since the setting values are Boolean type, you can use any of `TRUE`, `FALSE`, `1`, and `0`. Use commas for splitting multiple items. If an item is not explicitly specified in the **`OptionString`** parameter, the IVI-defined default value is applied for the item. The IVI-defined default values are TRUE for **`RangeCheck`** and **`Cache`**, and FALSE for others.

Some instrument drivers may have special meanings for the **`DriverSetup`** parameter. It can specify items that are not defined by the IVI specifications when invoking the **`Initialize`** method, and its purpose and syntax are driver-specific. Therefore, specifying the **`DriverSetup`** must be at the last part on the **`OptionString`** parameter. Because the contents of **`DriverSetup`** are different depending on each driver, refer to driver's Readme document or online help.

2-5 Closing Session

To close instrument driver session, use the **`Close`** method.

2-6 Execution

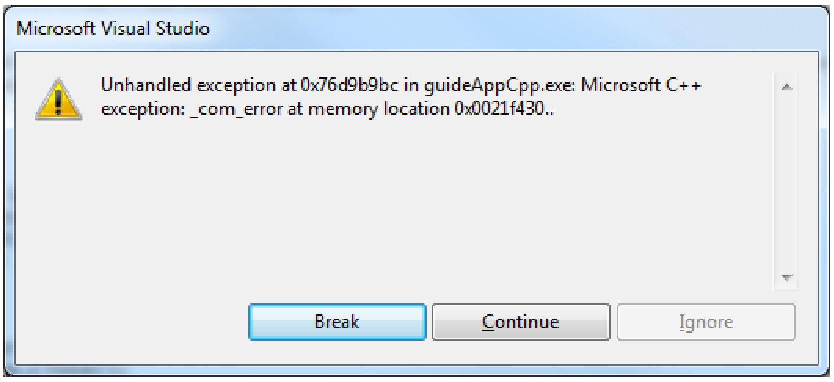
You can execute the previous codes for the time being.

```
// guideAppCpp.cpp : Defines the entry point for the console application.
//
```

```
#include "stdafx.h"

int _tmain(int argc, _TCHAR* argv[])
{
    HRESULT hr = CoInitializeEx( NULL, COINIT_MULTITHREADED);

    try {
        IKikusuiPwxPtr spInstr;

        hr = spInstr.CreateInstance( CLSID_KikusuiPwx);

        spInstr->Initialize(
            L"TCPIP::192.168.1.5::INSTR",
            VARIANT_TRUE,
            VARIANT_TRUE,
            L"QueryInstrStatys=1");

        spInstr->Close();
    }
    catch(...) {
    }

    CoUninitialize();

    return 0;
}
```

In this example codes, content of the **`_tmain`** function is executed linearly. If the instrument is actually connected and the **`Initialize`** method call has succeeded, the program will finish silently. However, if a communication problem has occurred or the VISA library is not configured properly, a COM exception (**`_com_error`**) will be generated. .

How to handle errors (exception) is explained later.


Microsoft Visual Studio

Unhandled exception at 0x76d9b9bc in guideAppCpp.exe: Microsoft C++ exception: _com_error at memory location 0x0021f430..

Figure 2-2 COM Exception

2-7 Repeated Capabilities, Output Collection

In case of IVI drivers for such as power supply or oscilloscope, the driver is designed assuming the instrument has multiple channels. Therefore for properties and methods that access instrument settings , there are a lot of cases that Repeated Capabilities (or Collection) are implemented. As for instrument drivers of DC power supplies, it is the **`Output`** collection.

For the case of KikusuiPwx IVI-COM driver, its concept is in **`KikusuiPwxOutputs`** and **`KikusuiPwxOutput`**. The plural name is the collection and singular name is each item (1 or more items) which may exist in the collection. In general an IVI instrument driver for DC power supply is designed assuming the instrument is a multi-track model.

They have the same name except for differences plural and singular forms. Like this, a component that has a plural name is generally called as Repeated Capabilities in the IVI spec. (Also called as Collection in COM terminology). The COM interface having plural name such as **IKikusuiPwxOutputs** normally has **Count**, **Name**, and **Item** properties (all read-only). **Count** property returns number of objects, **Name** property returns the name of the indexed object, and **Item** property returns reference to the object specified by a name. .

The following code example controls the output channel that is identified by **"Output0"** for the Kikusui PWX series DC supply.

```
...
IKikusuiPwxOutputPtr spOutput = spInstr->Outputs->Item[L"Output0"];
spOutput->VoltageLevel = 20.0;
spOutput->CurrentLimit = 2.0;
spOutput->Enabled = VARIANT_TRUE;...
```

Once the **IKikusuiPwxOutput** interface has been acquired, there is no difficulty at all. The **VoltageLevel** and the **CurrentLimit** properties set voltage level and current limit settings respectively. The **Enabled** property switches output ON/OFF state.

Mind the grammar for acquiring the **IKikusuiPwxOutput** interface. This example here acquires the **IKikusuiPwxOutputs** interface though the **Output** property of the **IKikusuiPwx** interface, then acquires **IKikusuiPwxOutput** interface by using the **Item** property.

Now mind the parameter passed to the **Item** property. This parameter specifies the name of the single **Output** object to be referenced. Actual available names (Output Name) are however different depending on drivers. For example, KikusuiPwx IVI-COM driver uses an expression like **"Output0"**. However other drivers, even if being IviDCPwr class-compliant, may have different names. One instrument driver, for example, may use an expression like **"Channel1"**. Although available names on a particular instrument driver are normally documented in the driver's online help, you can also check them out by writing some test codes shown below.

```
    IKikusuiPwxOutputsPtr spOutputs = spInstr->Outputs;
    int n;
    int c = spOutputs->Count;

     for( n=1; n<=c; n++) {
         _bstr_t name;
         name = spOutputs->Name[n];
         OutputDebugString( name);
     }
```

The **Count** property returns number of single objects that the repeated capabilities have. The **Name** property returns the name of single object for the given index. The name is exactly the one that can be passed to the **Item** property as a parameter. In the above example, the codes iterate from the index 1 to **Count** by using the `for` block. Mind that the index numbers for the **Name** parameter is one-based, not zero-based.

3- Error Handling

In the previous examples, there was no error handling processed. However, setting an out-of-range value to a property or invoking an unsupported function may generate an error from the instrument driver. Furthermore, no matter how the application is designed and implemented robustly, it is impossible to avoid instrument I/O communication errors.

When using IVI-COM instrument drivers, every error generated in the instrument driver is transmitted to the client program as a COM exception. In case of C++, a COM exception can be handled by using **try**, **catch**, blocks.

Now let's change the example of setting voltage and current as follows.

```
    try {
        HRESULT hr;
        IKikusuiPwxPtr spInstr;

        hr = spInstr.CreateInstance( CLSID_KikusuiPwx);

        spInstr->Initialize(
            L"TCPIP::192.168.1.5::INSTR",
            VARIANT_TRUE,
            VARIANT_TRUE,
            L"");

        IKikusuiPwxOutputPtr spOutput = spInstr->Outputs->Item["Output0"];
        spOutput->VoltageLevel = 20.0;
        spOutput->CurrentLimit = 2.0;
        spOutput->Enabled = true;

        spInstr->Close();
    }
    catch( _com_error e) {
        WCHAR msg[256];
        wsprintf( msg, L"%s, 0x%08x", (LPCWSTR)e.Description(), e.Error());
        OutputDebugString( msg);
    }

    catch( ...) {
    }
```

In this example, codes that may generates exceptions are written in the **try** block. For example, if the name passed to the **Item** property is wrong, if an out-of-range value is passed to **VoltageLevel**, or if an instrument communication error is generated, a COM exception will be generated in the instrument driver. Any exceptions generated inside the **try** block are handled in a **catch** block if corresponding block exists. (If no corresponding **Catch** block is fond, the process will be handled as an Unhandled Exception and the program will crash.) Above example just displays a simple message in the console when an exception has occurred.

4- Example Using Class Interface

Now we explain how to use class interfaces. By using class interfaces, you can swap the instruments without recompiling/relinking your application codes. In this case, however, IVI-COM instrument drivers for both pre-swap and post-swap models must be provided, and these drivers both must belong to the same instrument class. There is no interchangeability available between different instrument classes.

4-1 Virtual Instrument

What you have to do before creating an application that utilizes interchangeability features is create a virtual instrument. To realise interchangeability features, you should not write codes that are very specific to a particular IVI-COM instrument driver (e.g. creating an object instance directly as KikusuiPwx type) and should not write a specific VISA resource name such as "TCPIP::192.168.1.5::INSTR". Writing them directly in the application spoils interchangeability.

Instead, the IVI-COM specifications define methods to realise interchangeability by placing an external IVI configuration store. The application indirectly selects an instrument driver according to contents of the IVI Configuration Store, and accesses the indirectly loaded driver through the class interfaces.

The IVI Configuration Store is normally **C:/ProgramData/IVI Foundation/IVI /IviConfigurationStore.XML** file and is accessed through the IVI Configuration Server DLL. This DLL is mainly used by IVI instrument drivers and some VISA/IVI configuration tools, not by end-user applications. Instead, you can edit IVI driver configuration by using NI-MAX (NI Measurement and Automation Explorer) bundled with NI-VISA or IVI Configuration Utility bundled with KI-VISA.

Notes:

- As for how to edit virtual instrument settings using NI-MAX, refer to "IVI Instrument Driver Programming Guide (LabVIEW Edition or LabWindows/CVI Edition)".

This guidebook assumes that a virtual instrument having the logical name `mySupply` is already created, using KikusuiPwx driver, and using a VISA resource " TCPIP::192.168.1.5::INSTR ".

4-2 Importing Type Libraries

Similarly to the example using specific interfaces, create a new project of **Win32 Console Application** as C++ language.

What you should do first after creating a new project is, import type libraries for the IVI-COM instrument driver that you want to use. Open the **stdafx.h** file in your project, add the following **`#import`** lines after the existing #include lines.

```
#import "GlobMgr.dll" no_namespace named_guids
#import "IviDriverTypeLib.dll" no_namespace named_guids
#import "IviDCPwrTypeLib.dll" no_namespace named_guids

#import "IviSessionFactory.dll" no_namespace named_guids
```

Notes:

- In the above description, we did not specify full-path to the DLL file names. But when compiler cannot find these files, you need explicitly specify full-path in the #import lines or, configure the directory conditions in Visual C++ environment settings so that the DLL can be implicitly imported.
- GlobMgr.dll (VISA Global Resource Manager DLL) is found in "C:/Program Files (x86)/IVI Foundation/VISA/VisaCom" directory.
- IVI driver DLLs are found in "C:/Program Files (x86)/IVI Foundation/IVI/Bin" directory.

Once reference setting is completed, write the following code fragments. (Here write everything at once including the exception handlers mentioned before.)

```
int _tmain(int argc, _TCHAR* argv[])
{
    HRESULT hr = CoInitializeEx( NULL, COINIT_APARTMENTTHREADED);

    try {
        HRESULT hr;
        IIviDCPwrPtr spInstr;
        IIviSessionFactoryPtr spSf;

        hr = spSf.CreateInstance( CLSID_IviSessionFactory);
        spInstr = spSf->CreateDriver( L"mySupply");

        spInstr->Initialize( L"mySupply", VARIANT_TRUE, VARIANT_TRUE, L"");

        IIviDCPwrOutputPtr spOutput = spInstr->Outputs->Item[L"Track_A"];
        spOutput->VoltageLevel = 20.0;
        spOutput->CurrentLimit = 2.0;
        spOutput->Enabled = true;

        spInstr->Close();
    }
    catch( _com_error e) {
        WCHAR msg[256];
        wsprintf( msg, L"%s, 0x%04x", (LPCWSTR)e.Description(), e.Error());
        OutputDebugString( msg);
    }

    catch( ...) {
    }

    CoUninitialize();

    return 0;
}
```

Let's explain from the beginning.

4-3 Creating Object and Initializing Session

In contrast using specific interfaces, any dependency to specific components such as KikusuiPwx cannot be written. Instead, it creates an instance of **SessionFactory** object, and indirectly create a driver object that is configured in the IVI Configuration Store by using **CreateDriver** method.

Now create an **IviSessionFactory** object, then obtain the reference (smart pointer) to **IIviSessionFactory** interface.

```
    IIviSessionFactoryPtr spSf;
    hr = spSf.CreateInstance( CLSID_IviSessionFactory);
```

Next, invoke the **CreateDriver** method passing the IVI Logical Name (Virtual Instrument). The created object is actually an instance of KikusuiPwx driver, but here store the reference to **IIviDCPwr** interface into the variable **spInstr**.

```
    IIviDCPwrPtr spInstr = spSf->CreateDriver( L"mySupply");
```

If IVI Configuration Store is properly configured, the code will execute without generating exceptions. However, at this point of time, it has not communicate with the instrument yet. The DLL of IVI -COM driver is just loaded.

Then invoke **Initialize** method. At this point of time, communications with the instrument begins. The 1st parameter to **Initialize** method was originally a VISA address (VISA IO resource) but, here it shall be the IVI Logical Name. The IVI Configuration Store already knows the linked info concerning to this Logical Name, such as Hardware Asset, therefore the VISA address specified there will be actually applied.

```
spInstr->Initialize( L"mySupply", VARIANT_TRUE, VARIANT_TRUE, L"");
```

As for IviDCPwr class, the **Output** object of DC power supply is found in the **Outputs** collection. Similarly to the example of using specific interface, it obtains the reference to the single **Output** object from the collection. In this case, the interface type is **IIviDCPwrOutput** instead of **IKikusuiPwxOutput**.

```
        IIviDCPwrOutputPtr spOutput = spInstr->Outputs->Item[L"Track_A"];
        spOutput->VoltageLevel = 20.0;
        spOutput->CurrentLimit = 2.0;
        spOutput->Enabled = true;
```

Mind the parameter that is passed to **Item** parameter. This parameter specifies the name of single **Output** object that you want to reference to. In the example using specific interfaces it passed Physical Name that may be different by driver implementation basis, but not here. This example cannot use such Physical Names very specific to an instrument driver implementation (in fact it is possible to use but shall not to avoid spoiling interchangeability), so we use a Virtual Name.

The virtual name **"Track_A"** that is used in the above example is what specified to map to the physical name **"Output0"** in the IVI Configuration Store.

4-4 Exchanging Instrument

Example shown so far were set to use kipwx instrument driver as the virtual instrument configuration. Now what happens if changing the instrument to the one that is hosted by AgN57xx driver (Agilent N5700 series DC Power Supply)? In this case, you don't have to recompile/relink your application, however you have to change the configuration for IVI Logical Name (virtual instrument). Basically the configuration shall change:

- Software Module in Driver Session tab (kipwx➔AgN57xx)
- map target of Virtual Names (Output0➔Output1)
- IO Resource Descriptor in Hardware Asset (changing to the VISAaddress of post-swap instrument)
- Once the configuration is properly set, the above example will function with the post-swap instrument without having to recompile.

Once the configuration is properly set, the above example will function with the post-swap instrument without having to recompile.

Notes:

- For how to configure virtual instruments, refer to "IVI Instrument Driver Programming Guide (LabVIEW Edition or LabWindows/CVI Edition)".
- The interchangeablity feature utilizing IVI class drivers does not guarantee the correct operation between pre-swapping and post-swapping instruments. Please make sure to confirm that your system correctly functions after swapping the instruments.