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# SYCL Reference

Intel

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## LANGUAGE

SYCL programs are C++ programs. No extensions are added to the language.

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**Todo:** C++ version minimum

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### 1.1 Keywords

SYCL does not add any keywords to the C++ language.

### 1.2 Preprocessor Directives and Macros

Standard C++ preprocessing directives and macros are supported by the compiler. In addition, the SYCL Specification defines the SYCL specific preprocessor directives and macros.

The following preprocessor macros are supported by the compiler.

Macro	Value	Description
SYCL_DUMP_IMAGES	true or false	Instructs the runtime to dump the device image
SYCL_USE_KERNEL_SPV	<device binary>	Employ device binary to fulfill kernel launch request
SYCL_PROGRAM_BUILD_OPTIONS	<options>	Used to pass additional options for device program building.

### 1.3 Standard Library Classes Required for the Interface

The SYCL specification documents a facility to enable vendors to provide custom optimized implementations. Implementations require aliases for several STL interfaces. These are summarized as follows:

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**Todo:** add STL interfaces

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## PROGRAMMING INTERFACE

The Data Parallel C++ (DPC++) programming language and runtime consists of a set of C++ classes, templates, and libraries used to express a DPC++ program. This chapter provides a summary of the key classes, templates, and runtime libraries used to program.

### 2.1 Header File

### 2.2 Namespaces

### 2.3 Class Descriptions

The following sections provide further details on these items. These sections do not provide the exhaustive details found in the SYCL Specification. Instead, these sections provide:

- A summary that includes a description and the purpose
- Comments on the different constructors, if applicable
- Member function information, if applicable
- Special cases to consider with the DPC++ implementation compared to the SYCL Specification

For further details on SYCL, see the [SYCL Specification](#).

#### 2.3.1 Runtime Classes

##### 2.3.1.1 `device_selector`

```
class device_selector();
```

### Member functions

<i>(constructor)</i>	
<i>(destructor)</i>	
<i>select_device</i>	

### Non-member functions

<code>operator()</code>	
-------------------------	--

#### **(constructor)**

```
device_selector(const device_selector &rhs);  
device_selector &operator=(const device_selector &rhs);
```

#### **(destructor)**

```
virtual ~device_selector();
```

#### **select\_device**

```
device select_device() const;
```

### Return value

#### **operator()**

```
virtual int operator()(const device &device) const = 0;
```

### Return value

#### **2.3.1.2 platform**

```
class platform;
```

Abstraction for SYCL platform.



## Member functions

<i>(constructor)</i>	constructs a platform
<i>(destructor)</i>	destroys a platform
<i>get</i>	returns OpenCL platform ID
<i>get_devices</i>	returns devices bound to the platform
<i>get_info</i>	queries properties of the platform
<i>has_extension</i>	checks if platform has an extension
<i>is_host</i>	checks if platform has a SYCL host device

## Non-member functions

<i>get_platforms</i>	returns available platforms
----------------------	-----------------------------

## Example

Demonstrates several methods for platform

```
#include <CL/sycl.hpp>

namespace sycl = cl::sycl;

int main() {
    auto platforms = sycl::platform::get_platforms();

    for (auto &platform : platforms) {
        std::cout << "Platform: "
                  << platform.get_info<sycl::info::platform::name>()
                  << std::endl;

        auto devices = platform.get_devices();
        for (auto &device : devices) {
            std::cout << "  Device: "
                      << device.get_info<sycl::info::device::name>()
                      << std::endl;
        }
    }

    return 0;
}
```

Output:

```
Platform: Intel(R) FPGA Emulation Platform for OpenCL(TM)
  Device: Intel(R) FPGA Emulation Device
Platform: Intel(R) OpenCL
  Device: Intel(R) Core(TM) i5-7300U CPU @ 2.60GHz
Platform: Intel(R) CPU Runtime for OpenCL(TM) Applications
  Device: Intel(R) Core(TM) i5-7300U CPU @ 2.60GHz
Platform: SYCL host platform
  Device: SYCL host device
```

### (constructor)

```
platform();  
explicit platform(cl_platform_id platformID); 1  
explicit platform(const device_selector &deviceSelector); 2
```

Constructs a platform handle.

### Arguments

platformID	OpenCL platform ID
deviceSelector	Platform must contain the selected device

### get

```
cl_platform_id get() const;
```

Returns OpenCL platform id used in the constructor.

### get\_devices

```
vector_class<device> get_devices(  
    info::device_type = info::device_type::all) const;
```

Returns vector of devices of the requested type

### Arguments

device_type	limits type of device returned
-------------	--------------------------------

### Return value

vector containing devices of the specified type bound to the platform.

### Example

See *Example*.

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<sup>1</sup> Constructs a SYCL platform that retains an OpenCL id

<sup>2</sup> Selects a platform that contains the desired device

**get\_info**

```
template< info::platform param >
typename info::param_traits<info::platform, param>::return_type get_info() const;
```

Returns information about the platform, as specified by `param`.

**Return value**

Requested information

**Example**

See *Example*.

**has\_extension**

```
bool has_extension(const string_class &extension) const;
```

Checks if the platform has the requested extension.

**Arguments**

extension	
-----------	--

**Return value**

true if the platform has extension

**is\_host**

```
bool is_host() const;
```

Checks if the platform contains a SYCL *host device*

**Return value**

true if the platform contains a host device

## get\_platforms

```
static vector_class<platform> get_platforms();
```

Returns vector of platforms

### Return value

vector\_class containing SYCL platforms bound to the system

### Example

See *Example*.

## 2.3.1.3 context

```
class context;
```

### Member functions

<i>(constructor)</i>	constructs a context
<i>get</i>	returns OpenCL context ID
<i>is_host</i>	checks if contains a SYCL host device
<i>get_platform</i>	
<i>get_devices</i>	returns devices bound to the context
<i>get_info</i>	queries properties

### (constructor)

```
explicit context(const property_list &propList = {});
context(async_handler asyncHandler,
        const property_list &propList = {});
context(const device &dev, const property_list &propList = {});
context(const device &dev, async_handler asyncHandler,
        const property_list &propList = {});
context(const platform &plt, const property_list &propList = {});
context(const platform &plt, async_handler asyncHandler,
        const property_list &propList = {});
context(const vector_class<device> &deviceList,
        const property_list &propList = {});
context(const vector_class<device> &deviceList,
        async_handler asyncHandler, const property_list &propList = {});
context(cl_context clContext, async_handler asyncHandler = {});
```

## Arguments

propList	
asyncHandler	
dev	
plt	
deviceList	

### get

```
cl_context get() const;
```

### Return value

#### is\_host

```
bool is_host() const;
```

### Return value

#### get\_platform

```
platform get_platform() const;
```

### Return value

#### get\_devices

```
vector_class<device> get_devices() const;
```

### Return value

#### get\_info

```
template <info::context param>
typename info::param_traits<info::context, param>::return_type get_info() const;
```

## Return value

### 2.3.1.4 device

```
class device;
```

## Member functions

<i>(constructor)</i>	
<i>(destructor)</i>	
<i>get</i>	
<i>is_host</i>	
<i>is_cpu</i>	
<i>is_gpu</i>	
<i>is_accelerator</i>	
<i>get_platform</i>	
<i>get_info</i>	
<i>has_extension</i>	
<i>create_sub_devices</i>	

## Non-member functions

<i>get_devices</i>	
--------------------	--

## (constructor)

```
device();  
explicit device(cl_device_id deviceId);  
explicit device(const device_selector &deviceSelector);
```

## Arguments

deviceId	
deviceSelector	

## get

```
cl_device_id get() const;
```

**Return value****is\_host**

```
bool is_host() const;
```

**Return value****is\_cpu**

```
bool is_cpu() const;
```

**Return value****is\_gpu**

```
bool is_gpu() const;
```

**Return value****is\_accelerator**

```
bool is_accelerator() const;
```

**Return value****get\_platform**

```
platform get_platform() const;
```

**Return value****get\_info**

```
template <info::device param>  
typename info::param_traits<info::device, param>::return_type  
get_info() const;
```

## Return value

## Example

See *Example*.

## has\_extension

```
bool has_extension(const string_class &extension) const;
```

## Arguments

extension	
-----------	--

## Return value

## create\_sub\_devices

```
template <info::partition_property prop>  
vector_class<device> create_sub_devices(size_t nbSubDev) const; 4
```

```
template <info::partition_property prop>  
vector_class<device> create_sub_devices(const vector_class<size_t> &counts) └  
    ↪ const; 5
```

```
template <info::partition_property prop>  
vector_class<device> create_sub_devices(info::affinity_domain affinityDomain) └  
    ↪ const; 6
```

## Arguments

nbSubDev	
counts	
affinityDomain	

---

<sup>4</sup> Available only when `prop == info::partition_property::partition_equally`

<sup>5</sup> Available only when `prop == info::partition_property::partition_by_counts`

<sup>6</sup> Available only when `prop == info::partition_property::partition_by_affinity_domain`



## Return value

### get\_devices

```
static vector_class<device> get_devices(
    info::device_type deviceType = info::device_type::all);
```

## Return value

### 2.3.1.5 queue

```
class queue;
```

## Member functions

<i>(constructor)</i>	
<b>(destructor)</b>	
<i>get</i>	
<i>get_context</i>	
<i>get_device</i>	
<i>get_info</i>	
<i>is_host</i>	
<i>submit</i>	
<i>wait</i>	
<i>wait_and_throw</i>	
<i>throw_asynchronous</i>	

### (constructor)

```
explicit queue(const property_list &propList = {});
explicit queue(const async_handler &asyncHandler,
               const property_list &propList = {});
explicit queue(const device_selector &deviceSelector,
               const property_list &propList = {});
explicit queue(const device_selector &deviceSelector,
               const async_handler &asyncHandler,
               const property_list &propList = {});
explicit queue(const device &syclDevice, const property_list &propList = {});
explicit queue(const device &syclDevice, const async_handler &asyncHandler,
               const property_list &propList = {});
explicit queue(const context &syclContext,
               const device_selector &deviceSelector,
               const property_list &propList = {});
explicit queue(const context &syclContext,
               const device_selector &deviceSelector,
               const async_handler &asyncHandler,
               const property_list &propList = {});
explicit queue(const context &syclContext,
               const device &syclDevice,
```

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```
        const property_list &propList = {});  
explicit queue(const context &syclContext, const device &syclDevice,  
        const async_handler &asyncHandler,  
        const property_list &propList = {});  
explicit queue(cl_command_queue clQueue, const context& syclContext,  
        const async_handler &asyncHandler = {});
```

### **get**

```
cl_command_queue get() const;
```

### **Return value**

#### **get\_context**

```
context get_context() const;
```

### **Return value**

#### **get\_device**

```
device get_device() const;
```

### **Return value**

#### **is\_host**

```
bool is_host() const;
```

### **Return value**

#### **get\_info**

```
template <info::queue param>  
typename info::param_traits<info::queue, param>::return_type get_info() const;
```

**Return value****submit**

```
template <typename T>
event submit(T cgf);

template <typename T>
event submit(T cgf, const queue &secondaryQueue);
```

**Arguments**

cgf	
secondaryQueue	

**Return value****wait**

```
void wait();
```

**wait\_and\_throw**

```
void wait_and_throw();
```

**throw\_asynchronous**

```
void throw_asynchronous();
```

**2.3.1.6 event**

```
class event;
```

**Member functions**

<i>(constructor)</i>	
<i>(destructor)</i>	
<i>cl_event_get</i>	
<i>is_host</i>	
<i>get_wait_list</i>	
<i>wait</i>	
<i>wait_and_throw</i>	
<i>get_info</i>	
<i>get_profiling_info</i>	

### (constructor)

```
event();  
event(cl_event clEvent, const context& syclContext);
```

### cl\_event\_get

```
cl_event get();
```

### Return value

#### is\_host

```
bool is_host() const;
```

### Return value

#### get\_wait\_list

```
vector_class<event> get_wait_list();
```

### Return value

#### wait

```
void wait();  
static void wait(const vector_class<event> &eventList);
```

#### wait\_and\_throw

```
void wait_and_throw();  
static void wait_and_throw(const vector_class<event> &eventList);
```

### get\_info

```
template <info::event param>
typename info::param_traits<info::event, param>::return_type get_info() const;
```

#### Return value

### get\_profiling\_info

```
template <info::event_profiling param>
typename info::param_traits<info::event_profiling, param>::return_type get_profiling_
↪info() const;
```

#### Return value

## 2.3.2 Data Access

### 2.3.2.1 accessor

```
template<
    typename dataT,
    int dimensions,
    access::mode accessmode,
    access::target accessTarget = access::target::global_buffer,
    access::placeholder isPlaceholder = access::placeholder::false_t
> accessor;
```

A DPC++ `accessor` encapsulates reading and writing memory objects which can be buffers, images, or device local memory. Creating an accessor requires a method to reference the desired access target. Construction also requires the type of the memory object, the dimensionality of the memory object, the access mode, and a placeholder argument.

#### Template parameters

<code>dataT</code>	type of buffer element
<code>dimensions</code>	dimensionality of buffer
<code>accessmode</code>	type of access
<code>accessTarget</code>	type of memory
<code>isPlaceholder</code>	placeholder

## Member types

value_type	dataT
reference	dataT&
const_reference	const dataT&

## Member functions

(constructor)	constructs an accessor
(destructor)	destroys the accessor
is_placeholder	
<i>get_size</i>	
<i>get_count</i>	
get_range	
get_offset	

### get\_size

```
size_t get_size() const
```

Description

### get\_count

```
size_t get_size() const 1  
size_t get_size(int b) const 2  
size_t get_size(int c, int d) const 3
```

Description

---

<sup>1</sup> No arguments

<sup>2</sup> single argument

<sup>3</sup> 2 arguments

## GLOSSARY

**accelerator** Specialized component containing compute resources that can quickly execute a subset of operations. Examples include CPU, FPGA, GPU. See also: *device*

**accessor** Communicates the desired location (host, device) and mode (read, write) of access.

**application scope** Code that executes on the host.

**buffers** Memory object that communicates the type and number of items of that type to be communicated to the device for computation.

**command group scope** Code that acts as the interface between the host and device.

**command queue** Issues command groups concurrently.

**compute unit** A grouping of processing elements into a ‘core’ that contains shared elements for use between the processing elements and with faster access than memory residing on other compute units on the device.

**device** An accelerator or specialized component containing compute resources that can quickly execute a subset of operations. A CPU can be employed as a device, but when it is, it is being employed as an accelerator. Examples include CPU, FPGA, GPU. See also: *accelerator*

**device code** Code that executes on the device rather than the host. Device code is specified via lambda expression, functor, or kernel class.

**fat binary** Application binary that contains device code for multiple devices. The binary includes both the generic code (SPIR-V representation) and target specific executable code.

**fat library** Archive or library of object code that contains object code for multiple devices. The fat library includes both the generic object (SPIR-V representation) and target specific object code.

**fat object** File that contains object code for multiple devices. The fat object includes both the generic object (SPIR-V representation) and target specific object code.

**host** A CPU-based system (computer) that executes the primary portion of a program, specifically the application scope and command group scope.

**host device** A SYCL device that is always present and usually executes on the host CPU.

**host code** Code that is compiled by the host compiler and executes on the host rather than the device.

**images** Formatted opaque memory object that is accessed via built-in function. Typically pertains to pictures comprised of pixels stored in format like RGB.

**kernel scope** Code that executes on the device.

**nd-range** Short for N-Dimensional Range, a group of kernel instances, or work item, across one, two, or three dimensions.

**processing element** Individual engine for computation that makes up a compute unit.

**single source** Code in the same file that can execute on a host and accelerator(s).

**SPIR-V** Binary intermediate language for representing graphical-shader stages and compute kernels.

**sub-group** Sub-groups are an Intel extension.

**work-group** Collection of work-items that execute on a compute unit.

**work-item** Basic unit of computation in the oneAPI programming model. It is associated with a kernel which executes on the processing element.



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