

# Android USB Camera(2) : UVC协议分析

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目录(?)

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## 1. 前言

本文对USB的功能类协议USB Video Class ( UVC ) 的具体设计进行介绍，但不会介绍USB基础协议，所以需要<sup>1</sup>对USB基础协议有一定的了解，包括USB四大描述符以及四种传输方式。分析usb协议的重点在于描述符，这里将以实际设备的描述符为线索，贯穿、分析uvc协议。

## 2. UVC功能概述

UVC设备都是多Interface设备，这点同普通的u盘不同。UVC设备最起码有两个Interface，VideoControl ( VC ) Interface和VideoStream(VS) Interface；这也是最常见的UVC设备。Spec明确要求一个具有可用的，具有实际UVC功能的设备要有一个VC Interface，一个或多个VS Interface。

VCInterface用于进行配置，操控，设置UVC设备进入不同的功能状态，而VSInterface则负责视频数据流的传输；完整的UVC功能需依赖VS，VC Interfaces的配合才能实现。

## 3. IAD以及Interfaces

UVC功能需要使用一个VC Interface和一个或多个VS Interface的配合。Spec明确要求UVC设备必须使用一个Interface Association Descriptor ( IAD ) 来描述这个包含了VC和VS的Interfaces集合。

此外USB协议中并没有专门朝设备索取IAD的命令，IAD需作为Configuration描述符的一部分发送给Host端。在该Configuration描述符的排列顺序中，IAD要放在它所包含的VC,VS描述符之前，且同一个IAD中所有的VC,VS Interface的Interface number必须连贯。

```
1  ===>Device Descriptor<===
2  ...
3
4  ===>Configuration Descriptor<===
5  ...
6
7  ===>IAD Descriptor<===
8  bLength: 0x08
9  bDescriptorType: 0x0B
10 bFirstInterface: 0x00
11 bInterfaceCount: 0x02
12 bFunctionClass: 0x0E -> Video Interface Class
13 bFunctionSubClass: 0x03 -> Video Interface Collection
14 bFunctionProtocol: 0x00 -> PC_PROTOCOL_UNDEFINED protocol
15 iFunction: 0x00
16
17 ===>Interface Descriptor<===
18 bLength: 0x09
19 bDescriptorType: 0x04
20 bInterfaceNumber: 0x00
21 bAlternateSetting: 0x00
22 bNumEndpoints: 0x01
23 bInterfaceClass: 0x0E -> Video Interface Class
24 bInterfaceSubClass: 0x01 -> Video Control Interface SubClass
25 bInterfaceProtocol: 0x00
26 iInterface: 0x00
27 ...
28
29 ===>Interface Descriptor<===
30 bLength: 0x09
31 bDescriptorType: 0x04
32 bInterfaceNumber: 0x01
33 bAlternateSetting: 0x00
34 bNumEndpoints: 0x00
35 bInterfaceClass: 0x0E -> Video Interface Class
36 bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
37 bInterfaceProtocol: 0x00
38 iInterface: 0x00
39 ...
40
41 ===>IAD Descriptor<===
42 bLength: 0x08
43 bDescriptorType: 0x0B
44 bFirstInterface: 0x02
45 bInterfaceCount: 0x02
46 bFunctionClass: 0x01 -> Audio Interface Class
47 bFunctionSubClass: 0x01 -> Audio Control Interface SubClass
48 bFunctionProtocol: 0x00
49
```

```

50 iFunction: 0x04
51 English (United States) "USB2.0 MIC"
52
53 ===>Interface Descriptor<===
54 bLength: 0x09
55 bDescriptorType: 0x04
56 bInterfaceNumber: 0x02
57 bAlternateSetting: 0x00
58 bNumEndpoints: 0x00
59 bInterfaceClass: 0x01 -> Audio Interface Class
60 bInterfaceSubClass: 0x01 -> Audio Control Interface SubClass
61 bInterfaceProtocol: 0x00
62 CAUTION: This may be an invalid bInterfaceProtocol
63 iInterface: 0x04
64 English (United States) "USB2.0 MIC"
65 ...
66
67 ===>Interface Descriptor<===
68 bLength: 0x09
69 bDescriptorType: 0x04
70 bInterfaceNumber: 0x03
71 bAlternateSetting: 0x00
72 bNumEndpoints: 0x00
73 bInterfaceClass: 0x01 -> Audio Interface Class
74 bInterfaceSubClass: 0x02 -> Audio Streaming Interface SubClass
75 bInterfaceProtocol: 0x00
76 CAUTION: This may be an invalid bInterfaceProtocol
77 iInterface: 0x04
78 English (United States) "USB2.0 MIC"
...

```

可以看到我所使用的uvc设备包含两个IAD，第一个IAD是视频输入设备，也就是摄像头。第二个IAD是音频输入设备，也就是麦克风，暂时忽略这个IAD。重点分析第一个IAD，它包含了两个Interface，一个VC Interface和一个VS Interface

## 4. VC Interface

VC主要用于控制UVC功能中的Units和Terminals，通过对不同的Units和Terminals发下不同的指令，从而影响UVC设备的当前工作状态；Host端发下的所有对UVC设备的操纵控制命令都是经由此Interface完成的

```

1 ===>Interface Descriptor<===
2 bLength: 0x09

```

```

3  bDescriptorType: 0x04
4  bInterfaceNumber: 0x00
5  bAlternateSetting: 0x00
6  bNumEndpoints: 0x01
7  bInterfaceClass: 0x0E -> Video Interface Class
8  bInterfaceSubClass: 0x01 -> Video Control Interface SubClass
9  bInterfaceProtocol: 0x00
10 iInterface: 0x00
11
12 ===>Class-Specific Video Control Interface Header Descriptor<===
13 bLength: 0x0D
14 bDescriptorType: 0x24
15 bDescriptorSubtype: 0x01
16 bcdVDC: 0x0100
17 wTotalLength: 0x0033 -> Validated
18 dwClockFreq: 0x02DC6C00 = (48000000) Hz
19 bInCollection: 0x01
20 baInterfaceNr[1]: 0x01
21 USB Video Class device: spec version 1.0
22
23 ===>Video Control Input Terminal Descriptor<===
24 ...
25
26 ===>Video Control Processing Unit Descriptor<===
27 ...
28
29 ===>Video Control Output Terminal Descriptor<===
30 ...
31
32 ===>Endpoint Descriptor<===
33 bLength: 0x07
34 bDescriptorType: 0x05
35 bEndpointAddress: 0x81 -> Direction: IN - EndpointID: 1
36 bmAttributes: 0x03 -> Interrupt Transfer Type
37 wMaxPacketSize: 0x0010 = 1 transactions per microframe, 0x10 max bytes
38 bInterval: 0x0A
39
40 ===>Class-specific VC Interrupt Endpoint Descriptor<===
41 bLength: 0x05
42 bDescriptorType: 0x25
43 bDescriptorSubtype: 0x03
44 wMaxTransferSize: 0x0010 = (16) Bytes

```

这个设备包含了一个Processing Unit、一个Input Terminal和Output Terminal，VC Interface需要对它们下发不同的命令，为此VC Interface需要包含一个控制端点（强制性要求），它使用的就是每个USB设备中默认的端点0。

另外一个Interrupt端点则是可选的，用来返回或通知Host端当前的UVC设备内部状态有变化。大部分情况下，一个UVC设备的VC Interface不需一定要实现此端点，但一旦UVC设备需要实现某些特定feature时，Spec会强制性要求实现该interrupt端点。

## 5. UVC设备内的各种Entity

UVC的Spec在制定时考虑到了诸多不同UVC设备可能存在的特性，为保证Spec具有最大范围的适用性和兼容性，将UVC设备内可能存在的每个功能模块划分为逻辑意义上的功能单元（Entity），并要求具体UVC设备的开发者必须为每个Entity指定ID号，且该ID号能唯一标识某一指定的功能单元，以便Host端的UVC驱动能依此对设备内不同的功能单元进行操作和配置。

Entity粗略可划分为Unit，Terminal两种。这都是逻辑意义上的划分，它们对应UVC设备内的某个功能单元。

### 5.1 Unit

Unit可以理解为构建出UVC设备功能的各功能单元，多个Unit按照一定的规则连接后就是一个完整的UVC功能设备。Spec规定Unit有一个或多个入口，一个出口；也就是说可以有多个Unit或Terminal作为一个Unit的输入源头，而数据在流经Unit后仅能作为其他Unit或Terminal的一个输入源头。

Spec中定义了三种Unit：Selector Unit (SU)，Processing Unit (PU)，Extension Unit (EU)。

```
1  ===>Video Control Processing Unit Descriptor<===
2  bLength: 0x0B
3  bDescriptorType: 0x24
4  bDescriptorSubtype: 0x05
5  bUnitID: 0x02
6  bSourceID: 0x01
7  wMaxMultiplier: 0x0000
8  bControlSize: 0x02
9  bmControls : 0x3F 0x06
10 D00 = 1 yes - Brightness
11 D01 = 1 yes - Contrast
12 D02 = 1 yes - Hue
13 D03 = 1 yes - Saturation
14 D04 = 1 yes - Sharpness
15 D05 = 1 yes - Gamma
16 D06 = 0 no - White Balance Temperature
17
```

```
18 D07 = 0 no - White Balance Component
19 D08 = 0 no - Backlight Compensation
20 D09 = 1 yes - Gain
21 D10 = 1 yes - Power Line Frequency
22 D11 = 0 no - Hue, Auto
23 D12 = 0 no - White Balance Temperature, Auto
24 D13 = 0 no - White Balance Component, Auto
25 D14 = 0 no - Digital Multiplier
26 D15 = 0 no - Digital Multiplier Limit
    iProcessing : 0x00
```

Processing Unit则代表了对采集的数据进行处理的单元，负责对采集到的图像特性进行调整设置，当Host端要求设定这些Processing Unit负责范围内的功能特性时，Processing Unit作为指定的命令响应者就需要对之进行响应和调整。

Spec定义中要求PU单元负责响应Host端对如下图像特性方面的设置调整要求（在该UVC设备确实支持这些特性可变，可供设置的前提下）

#### Usr Controls

- Brightness
- Contrast
- Hue
- Saturatio
- Sharpness
- Gamma
- Digital Multiplier (Zoom)

#### Auto Controls

- White Balance Temperature
- White Balance Component
- Blcklight Compensation

#### Other

- Gain
- Power Line Frequency
- Analog Video Standard

- Analog Video Lock Status

## 5.2 Terminal

Terminal是指整个UVC功能的入口和出口，逻辑意义上讲Terminal只有一个出口或者入口，它要么代表整个UVC功能的数据输入点，要么代表数据在流经UVC功能内部的各Unit功能单元后的最终流入点。

Spec中定义了两种Terminal：Input Terminal，Output Terminal。

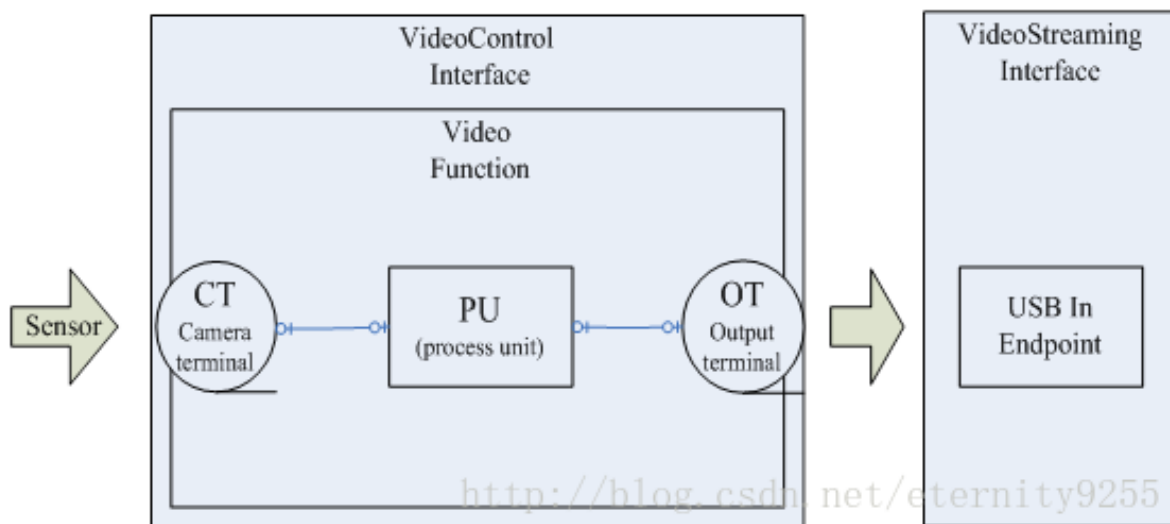
```
1  ===>Video Control Input Terminal Descriptor<===
2  bLength: 0x12
3  bDescriptorType: 0x24
4  bDescriptorSubtype: 0x02
5  bTerminalID: 0x01
6  wTerminalType: 0x0201 = (ITT_CAMERA)
7  bAssocTerminal: 0x00
8  iTerminal: 0x00
9  ===>Camera Input Terminal Data
10 wObjectiveFocalLengthMin: 0x0000
11 wObjectiveFocalLengthMax: 0x0000
12 wOcularFocalLength: 0x0000
13 bControlSize: 0x03
14 bmControls : 0x00 0x00 0x00
15 D00 = 0 no - Scanning Mode
16 D01 = 0 no - Auto-Exposure Mode
17 D02 = 0 no - Auto-Exposure Priority
18 D03 = 0 no - Exposure Time (Absolute)
19 D04 = 0 no - Exposure Time (Relative)
20 D05 = 0 no - Focus (Absolute)
21 D06 = 0 no - Focus (Relative)
22 D07 = 0 no - Iris (Absolute)
23 D08 = 0 no - Iris (Relative)
24 D09 = 0 no - Zoom (Absolute)
25 D10 = 0 no - Zoom (Relative)
26 D11 = 0 no - Pan (Absolute)
27 D12 = 0 no - Pan (Relative)
28 D13 = 0 no - Roll (Absolute)
29 D14 = 0 no - Roll (Relative)
30 D15 = 0 no - Tilt (Absolute)
31 D16 = 0 no - Tilt (Relative)
32 D17 = 0 no - Focus Auto
33 D18 = 0 no - Reserved
34 D19 = 0 no - Reserved
35 D20 = 0 no - Reserved
36 D21 = 0 no - Reserved
37
```

```
38 D22 = 0 no - Reserved
    D23 = 0 no - Reserved
```

Input Terminal可以理解为整个UVC功能的数据源头，它仅有一个outPin，可以连接到其他Unit的Input Pin作为该Unit的输入源。

```
1 ===>Video Control Output Terminal Descriptor<===
2 bLength: 0x09
3 bDescriptorType: 0x24
4 bDescriptorSubtype: 0x03
5 bTerminalID: 0x03
6 wTerminalType: 0x0101 = (TT_STREAMING)
7 bAssocTerminal: 0x00
8 bSourceID: 0x02
9 iTerminal: 0x00
```

Output Terminal则可以理解为当图像数据流程UVC设备内部的整个处理流程后的输出点，它仅有一个Input Pin，整个UVC处理流程上的最后一个Unit会将它的Output Pin与Output Terminal的Input Pin连接在一起。



通过如上描述符所获得的信息，我们可以看出该USB Camera大致有三个逻辑功能意义上的Entity：CT(代表硬件上的图像数据采集源，Sensor)，PU（代表Sensor中可对采集所得图像数据进行加工的功能单元），OT(代表实际中USB模块的ISO In端点)，并无SU单元来控制图像数据采集源的切换和选择（只有一个输入源），此外也没有对采集所得的数据进行个性化处理的功能，故也没有EU单元的存在（无EU描述符）。



## 6. VS Interface

VS Interface则专注与负责传输UVC设备的Video数据到Host端。若一UVC设备支持n种格式的Video数据，则它需要实现n个VS Interface，每个Interface对应一种专门的数据格式；而每个VSInterface则必须包含一个ISO或bulk端点来传输Video数据，一个可选的bulk端点专门用于传输静态图片数据（在实现了第三种静态图片拍摄机制的前提下）。

```
1  ===>Interface Descriptor<===
2  bLength: 0x09
3  bDescriptorType: 0x04
4  bInterfaceNumber: 0x01
5  bAlternateSetting: 0x00
6  bNumEndpoints: 0x00
7  bInterfaceClass: 0x0E -> Video Interface Class
8  bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
9  bInterfaceProtocol: 0x00
10 iInterface: 0x00
11
12 ===>Video Class-Specific VS Video Input Header Descriptor<===
13 bLength: 0x0E
14 bDescriptorType: 0x24
15 bDescriptorSubtype: 0x01
16 bNumFormats: 0x01
17 wTotalLength: 0x010F -> Validated
18 bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
19 bmInfo: 0x00 -> Dynamic Format Change not Supported
20 bTerminalLink: 0x03
21 bStillCaptureMethod: 0x02 -> Still Capture Method 2
22 bTriggerSupport: 0x01 -> Hardware Triggering Support
23 bTriggerUsage: 0x00 -> Host will initiate still image capture
24 bControlSize: 0x01
25 Video Payload Format 1 0x00
26 D00 = 0 no - Key Frame Rate
27 D01 = 0 no - P Frame Rate
28 D02 = 0 no - Compression Quality
29 D03 = 0 no - Compression Window Size
30 D04 = 0 no - Generate Key Frame
31 D05 = 0 no - Update Frame Segment
32 D06 = 0 no - Reserved
33 D07 = 0 no - Reserved
34
35 ===>Video Streaming MJPEG Format Type Descriptor<===
36 bLength: 0x0B
37 bDescriptorType: 0x24
38 bDescriptorSubtype: 0x06
```

```
39  bFormatIndex: 0x01
40  bNumFrameDescriptors: 0x05
41  bmFlags: 0x01 -> Sample Size is Fixed
42  bDefaultFrameIndex: 0x01
43  bAspectRatioX: 0x00
44  bAspectRatioY: 0x00
45  bmInterlaceFlags: 0x00
46  D00 = 0 non-Interlaced stream or variable
47  D01 = 0 2 fields per frame
48  D02 = 0 Field 1 not first
49  D03 = 0 Reserved
50  D4..5 = 0 Field patterns -> Field 1 only
51  D6..7 = 0 Display Mode -> Bob only
52  bCopyProtect: 0x00 -> Duplication Unrestricted
53
54  ===>Video Streaming MJPEG Frame Type Descriptor<===
55  --->This is the Default (optimum) Frame index
56  bLength: 0x2A
57  bDescriptorType: 0x24
58  bDescriptorSubtype: 0x07
59  bFrameIndex: 0x01
60  bmCapabilities: 0x00
61  wWidth: 0x0280
62  wHeight: 0x01E0
63  dwMinBitRate: 0x0001F400
64  dwMaxBitRate: 0x00A8C000
65  dwMaxVideoFrameBufferSize: 0x00096000
66  dwDefaultFrameInterval: 0x00051615
67  bFrameIntervalType: 0x04
68  ===>Additional Discrete Frame TypeData
69  dwFrameInterval[1]: 0x00028B0A
70  dwFrameInterval[2]: 0x00051615
71  dwFrameInterval[3]: 0x000A2C2A
72  dwFrameInterval[4]: 0x001E8480
73
74  ===>Video Streaming MJPEG Frame Type Descriptor<===
75  bLength: 0x2A
76  bDescriptorType: 0x24
77  bDescriptorSubtype: 0x07
78  bFrameIndex: 0x02
79  bmCapabilities: 0x00
80  wWidth: 0x00A0
81  wHeight: 0x0078
82  dwMinBitRate: 0x0001F400
83  dwMaxBitRate: 0x00A8C000
84  dwMaxVideoFrameBufferSize: 0x00009600
85  dwDefaultFrameInterval: 0x00051615
86  bFrameIntervalType: 0x04
87  ===>Additional Discrete Frame TypeData
```

```
88  dwFrameInterval[1]: 0x00028B0A
89  dwFrameInterval[2]: 0x00051615
90  dwFrameInterval[3]: 0x000A2C2A
91  dwFrameInterval[4]: 0x001E8480
92
93  ===>Video Streaming MJPEG Frame Type Descriptor<===
94  bLength: 0x2A
95  bDescriptorType: 0x24
96  bDescriptorSubtype: 0x07
97  bFrameIndex: 0x03
98  bmCapabilities: 0x00
99  wWidth: 0x00B0
100 wHeight: 0x0090
101 dwMinBitRate: 0x0001F400
102 dwMaxBitRate: 0x00A8C000
103 dwMaxVideoFrameBufferSize: 0x0000C600
104 dwDefaultFrameInterval: 0x00051615
105 bFrameIntervalType: 0x04
106 ===>Additional Discrete Frame TypeData
107 dwFrameInterval[1]: 0x00028B0A
108 dwFrameInterval[2]: 0x00051615
109 dwFrameInterval[3]: 0x000A2C2A
110 dwFrameInterval[4]: 0x001E8480
111
112 ===>Video Streaming MJPEG Frame Type Descriptor<===
113 bLength: 0x2A
114 bDescriptorType: 0x24
115 bDescriptorSubtype: 0x07
116 bFrameIndex: 0x04
117 bmCapabilities: 0x00
118 wWidth: 0x0140
119 wHeight: 0x00F0
120 dwMinBitRate: 0x0001F400
121 dwMaxBitRate: 0x00A8C000
122 dwMaxVideoFrameBufferSize: 0x00025800
123 dwDefaultFrameInterval: 0x00051615
124 bFrameIntervalType: 0x04
125 ===>Additional Discrete Frame TypeData
126 dwFrameInterval[1]: 0x00028B0A
127 dwFrameInterval[2]: 0x00051615
128 dwFrameInterval[3]: 0x000A2C2A
129 dwFrameInterval[4]: 0x001E8480
130
131 ===>Video Streaming MJPEG Frame Type Descriptor<===
132 bLength: 0x2A
133 bDescriptorType: 0x24
134 bDescriptorSubtype: 0x07
135 bFrameIndex: 0x05
136 bmCapabilities: 0x00
```

```

137  wWidth: 0x0160
138  wHeight: 0x0120
139  dwMinBitRate: 0x0001F400
140  dwMaxBitRate: 0x00A8C000
141  dwMaxVideoFrameBufferSize: 0x00031800
142  dwDefaultFrameInterval: 0x00051615
143  bFrameIntervalType: 0x04
144  ===>Additional Discrete Frame TypeData
145  dwFrameInterval[1]: 0x00028B0A
146  dwFrameInterval[2]: 0x00051615
147  dwFrameInterval[3]: 0x000A2C2A
148  dwFrameInterval[4]: 0x001E8480

```

可以看出这个设备只支持一种视频格式“ MJPEG” ，所以它只有一个VS Interface，而同一种视频格式下有很多参数可以调整，比如说图像分辨率，每秒的帧速率等。其参数组合信息就是紧跟在Format Type Descriptor之后的Frame Type Descriptor。

在采用不同的参数组合时，UVC设备进行数据传输时，所需占用的USB数据带宽显然有很大的不同；因此一个VS Interface下需要有多组setting，每个setting对应一个固定的Video参数设置组合，也就对应了一个固定参数值的Video数据，该setting下每秒要传输的帧数（帧速率），图像分辨率等均固定，进而对USB的带宽要求也固定。

```

1  ===>Interface Descriptor<===
2  bLength: 0x09
3  bDescriptorType: 0x04
4  bInterfaceNumber: 0x01
5  bAlternateSetting: 0x01
6  bNumEndpoints: 0x01
7  bInterfaceClass: 0x0E -> Video Interface Class
8  bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
9  bInterfaceProtocol: 0x00
10 iInterface: 0x00
11
12 ===>Endpoint Descriptor<===
13 bLength: 0x07
14 bDescriptorType: 0x05
15 bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
16 bmAttributes: 0x05 -> Isochronous Transfer Type
17 Synchronization Type = Asynchronous
18 Bulk Transfer Type
19 wMaxPacketSize: 0x00C0 = 1 transactions per microframe, 0xC0 max bytes
20 bInterval: 0x01
21

```

```
22  ===>Interface Descriptor<===
23  bLength: 0x09
24  bDescriptorType: 0x04
25  bInterfaceNumber: 0x01
26  bAlternateSetting: 0x02
27  bNumEndpoints: 0x01
28  bInterfaceClass: 0x0E -> Video Interface Class
29  bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
30  bInterfaceProtocol: 0x00
31  iInterface: 0x00
32
33  ===>Endpoint Descriptor<===
34  bLength: 0x07
35  bDescriptorType: 0x05
36  bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
37  bmAttributes: 0x05 -> Isochronous Transfer Type
38  Synchronization Type = Asynchronous
39  Bulk Transfer Type
40  wMaxPacketSize: 0x0180 = 1 transactions per microframe, 0x180 max bytes
41  bInterval: 0x01
42
43  ===>Interface Descriptor<===
44  bLength: 0x09
45  bDescriptorType: 0x04
46  bInterfaceNumber: 0x01
47  bAlternateSetting: 0x03
48  bNumEndpoints: 0x01
49  bInterfaceClass: 0x0E -> Video Interface Class
50  bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
51  bInterfaceProtocol: 0x00
52  iInterface: 0x00
53
54  ===>Endpoint Descriptor<===
55  bLength: 0x07
56  bDescriptorType: 0x05
57  bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
58  bmAttributes: 0x05 -> Isochronous Transfer Type
59  Synchronization Type = Asynchronous
60  Bulk Transfer Type
61  wMaxPacketSize: 0x0200 = 1 transactions per microframe, 0x200 max bytes
62  bInterval: 0x01
63
64  ===>Interface Descriptor<===
65  bLength: 0x09
66  bDescriptorType: 0x04
67  bInterfaceNumber: 0x01
68  bAlternateSetting: 0x04
69  bNumEndpoints: 0x01
70  bInterfaceClass: 0x0E -> Video Interface Class
```

```
71 bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
72 bInterfaceProtocol: 0x00
73 iInterface: 0x00
74
75 ===>Endpoint Descriptor<===
76 bLength: 0x07
77 bDescriptorType: 0x05
78 bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
79 bmAttributes: 0x05 -> Isochronous Transfer Type
80 Synchronization Type = Asynchronous
81 Bulk Transfer Type
82 wMaxPacketSize: 0x0280 = 1 transactions per microframe, 0x280 max bytes
83 bInterval: 0x01
84
85 ===>Interface Descriptor<===
86 bLength: 0x09
87 bDescriptorType: 0x04
88 bInterfaceNumber: 0x01
89 bAlternateSetting: 0x05
90 bNumEndpoints: 0x01
91 bInterfaceClass: 0x0E -> Video Interface Class
92 bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
93 bInterfaceProtocol: 0x00
94 iInterface: 0x00
95
96 ===>Endpoint Descriptor<===
97 bLength: 0x07
98 bDescriptorType: 0x05
99 bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
100 bmAttributes: 0x05 -> Isochronous Transfer Type
101 Synchronization Type = Asynchronous
102 Bulk Transfer Type
103 wMaxPacketSize: 0x0320 = 1 transactions per microframe, 0x320 max bytes
104 bInterval: 0x01
105
106 ===>Interface Descriptor<===
107 bLength: 0x09
108 bDescriptorType: 0x04
109 bInterfaceNumber: 0x01
110 bAlternateSetting: 0x06
111 bNumEndpoints: 0x01
112 bInterfaceClass: 0x0E -> Video Interface Class
113 bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
114 bInterfaceProtocol: 0x00
115 iInterface: 0x00
116
117 ===>Endpoint Descriptor<===
118 bLength: 0x07
119 bDescriptorType: 0x05
```

```
120 bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
121 bmAttributes: 0x05 -> Isochronous Transfer Type
122 Synchronization Type = Asynchronous
123 Bulk Transfer Type
124 wMaxPacketSize: 0x03C0 = 1 transactions per microframe, 0x3C0 max bytes
125 bInterval: 0x01
126
127 ===>Interface Descriptor<===
128 bLength: 0x09
129 bDescriptorType: 0x04
130 bInterfaceNumber: 0x01
131 bAlternateSetting: 0x07
132 bNumEndpoints: 0x01
133 bInterfaceClass: 0x0E -> Video Interface Class
134 bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
135 bInterfaceProtocol: 0x00
136 iInterface: 0x00
137
138 ===>Endpoint Descriptor<===
139 bLength: 0x07
140 bDescriptorType: 0x05
141 bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
142 bmAttributes: 0x05 -> Isochronous Transfer Type
143 Synchronization Type = Asynchronous
144 Bulk Transfer Type
145 wMaxPacketSize: 0x0A80 = 2 transactions per microframe, 0x280 max bytes
146 bInterval: 0x01
147
148 ===>Interface Descriptor<===
149 bLength: 0x09
150 bDescriptorType: 0x04
151 bInterfaceNumber: 0x01
152 bAlternateSetting: 0x08
153 bNumEndpoints: 0x01
154 bInterfaceClass: 0x0E -> Video Interface Class
155 bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
156 bInterfaceProtocol: 0x00
157 iInterface: 0x00
158
159 ===>Endpoint Descriptor<===
160 bLength: 0x07
161 bDescriptorType: 0x05
162 bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
163 bmAttributes: 0x05 -> Isochronous Transfer Type
164 Synchronization Type = Asynchronous
165 Bulk Transfer Type
166 wMaxPacketSize: 0x0B20 = 2 transactions per microframe, 0x320 max bytes
167 bInterval: 0x01
168
```

```
169 ===>Interface Descriptor<===
170 bLength: 0x09
171 bDescriptorType: 0x04
172 bInterfaceNumber: 0x01
173 bAlternateSetting: 0x09
174 bNumEndpoints: 0x01
175 bInterfaceClass: 0x0E -> Video Interface Class
176 bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
177 bInterfaceProtocol: 0x00
178 iInterface: 0x00
179
180 ===>Endpoint Descriptor<===
181 bLength: 0x07
182 bDescriptorType: 0x05
183 bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
184 bmAttributes: 0x05 -> Isochronous Transfer Type
185 Synchronization Type = Asynchronous
186 Bulk Transfer Type
187 wMaxPacketSize: 0x0BE0 = 2 transactions per microframe, 0x3E0 max bytes
188 bInterval: 0x01
189
190 ===>Interface Descriptor<===
191 bLength: 0x09
192 bDescriptorType: 0x04
193 bInterfaceNumber: 0x01
194 bAlternateSetting: 0x0A
195 bNumEndpoints: 0x01
196 bInterfaceClass: 0x0E -> Video Interface Class
197 bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
198 bInterfaceProtocol: 0x00
199 iInterface: 0x00
200
201 ===>Endpoint Descriptor<===
202 bLength: 0x07
203 bDescriptorType: 0x05
204 bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
205 bmAttributes: 0x05 -> Isochronous Transfer Type
206 Synchronization Type = Asynchronous
207 Bulk Transfer Type
208 wMaxPacketSize: 0x1380 = 3 transactions per microframe, 0x380 max bytes
209 bInterval: 0x01
210
211 ===>Interface Descriptor<===
212 bLength: 0x09
213 bDescriptorType: 0x04
214 bInterfaceNumber: 0x01
215 bAlternateSetting: 0x0B
216 bNumEndpoints: 0x01
217 bInterfaceClass: 0x0E -> Video Interface Class
```



```
218 bInterfaceSubClass: 0x02 -> Video Streaming Interface SubClass
219 bInterfaceProtocol: 0x00
220 iInterface: 0x00
221
222 ===>Endpoint Descriptor<===
223 bLength: 0x07
224 bDescriptorType: 0x05
225 bEndpointAddress: 0x83 -> Direction: IN - EndpointID: 3
226 bmAttributes: 0x05 -> Isochronous Transfer Type
227 Synchronization Type = Asynchronous
228 Bulk Transfer Type
229 wMaxPacketSize: 0x13E8 = 3 transactions per microframe, 0x3E8 max bytes
230 bInterval: 0x01
```

此外，对于每个VS Interface来讲，必须实现setting0，且setting0不代表任何实际的Video流和参数组合，当指定setting0时就是要求UVC设备暂停数据传输，放弃对USB带宽的占用。

## 7. 总结

UVC同MSC一样，系USB框架下的功能类协议，但却与MSC有着较大差异。MSC功能采用Control+Bulk传输完成，其枚举流程，描述符配置较为清晰，控制传输阶段简单，定义的类功能控制命令较少。而BULK传输阶段则较为复杂繁琐，出错机制，续传机制等要求较为严格。

而UVC则刚好相反，它采用Control+ISO传输机制实现（BULK和INTR机制为可选特性），其枚举流程，描述符配置较为复杂，繁琐，定义了诸多的类控制命令，Entity等；而具体的数据传输阶段即ISO传输较为简单。