Dawar Technologies

Introduction to USB-C

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1. Introduction

The first Universal Serial Bus (USB) was designed in 1996 as a replacement for RS-232, PS/2, and other communication standards used to connect peripheral devices to a PC. From the beginning, USB has provided industry-standard connector types, a common voltage, a communications protocol, and various communication speeds for connecting any device to a PC.

There have been multiple updates to the USB standards over the years to increase the bus speed, increase charging capabilities for phones and tablets, and add new connector types. In fact, most people tend to think of USB in terms of just the connector and cable that they need for some particular device: USB-A, USB-B, Mini-B, Micro-B, B Superspeed, Mini-B Superspeed, and so on. When USB-C products entered the market a few years ago, most people thought of USB-C as just another connector type to add to the list. But the USB-C standard is much more than just a new connector.

USB-C has expanded the capabilities of USB to cover a variety of new features including higher voltage and current, reversible power delivery, encoded video signals, active cables, and more. These new capabilities are just starting to be utilized in the marketplace. One of the first implementations to take advantage of the new USB-C capabilities are USB-C expansion ports for laptops which replace the older style snap-in docking stations. Just like the older docking stations, the new expansion ports have multiple outputs including USB ports, various video outputs, audio jacks, etc. The big difference between the older style docking stations and the new USB-C expansion ports is that the proprietary multi-pin snap-in connector is replaced by a single standard USB-C cable. That one USB-C cable is used to charge the laptop from the expansion port, to carry the video output signals from the laptop to the expansion port, to carry audio from the laptop to the expansion port, and to connect the USB bus in the laptop to a USB hub in the expansion port.

Dawar Technologies, a manufacturer of touch-centric display solutions, has developed a custom USB-C monitor driver board called Simple-C™. When integrated into one of Dawar Technologies' monitor products, our Simple-C board provides power, audio, video, and USB signals to the monitor all over just one USB-C cable. This means you only need one cable between your host computer and your Dawar Technologies Simple-C monitor.

This guide provides the basic background information needed to understand all the USB-C app notes and datasheets you will need when implementing your USB-C host design. The good news is that most of the details for creating a USB host connection are handled by the specific USB-C chip you select. Your main task will be configuring your USB-C chip so that it will work correctly with the Dawar Simple-C driver board. This document provides the background you need to understand these various configuration options.

To use Dawar's Simple-C board, the host system has to be designed to support a wide variety of the USB-C feature set. If you're already familiar with USB-C, please read our "Dawar Technologies Simple-C USB-C Driver Board User's Guide". It covers the specific features supported by our Simple-C board, the capabilities needed on the host side, some sample host chips you could use, various development tools, etc. If your are not familiar with USB-C, then this document provides the background you need on the various features of USB-C utilized by Simple-C.

2. USB-C Features

2.1. Reversible 24 Pin Connector

The first and most noticeable improvement of USB-C is the new connector footprint. Unlike every other USB connector before it, the USB-C connector is symmetrical which means it can be inserted in either orientation:

Figure 1: Plug

Figure 2: Receptacle

In addition, standard USB-C cables are reversible with the same USB-C connector on both ends, although there are also USB-A to USB-C cables available for connecting a smart phone (USB-C) to a PC or charger (USB-A).

The original USB connector only had four conductors: ground, power, data+ (D+), and data- (D-). The two data lines form one bi-directional differential-pair communications channel also known as a lane. The new USB-C connector has 24 conductors. In addition to ground and power pins, there are six differential pairs (or lanes) plus a few pins used for handshaking and other tasks. The connector and receptacle pinouts are covered in section 4.

The six data lanes enable USB-C to include many features that couldn't be supported by the single D+/D- lane in the original USB connector. The goal was to replace all of the connectors shown below with one USB-C connection:

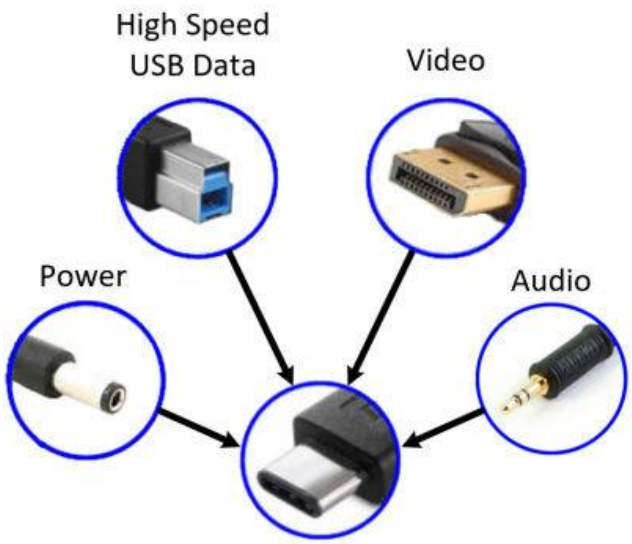

Figure 3: USB-C Replaces All These Connectors

2.2. High Power Delivery

One of the most useful improvements of USB-C is the ability to carry much higher power on the USB-C cable. The USB-C specification provides for up to 100 Watts of power delivery over a USB-C cable. The Dawar Simple-C board supports up to 60 Watts, which is delivered as 20 Volts at a maximum of 3 Amps.

Another key power improvement is that the USB-C specification allows power to flow both ways on the cable. A device can provide power to a host and a host can provide power to a device. And the power direction can change at run-time. When two USB-C capable products are connected to each other, they negotiate how much power will be provided and by whom. More information on power delivery negotiation is provided in section 6.

2.3. Alternate Mode Video

As mentioned earlier, there are multiple lanes of data on the new USB-C connector. One of the benefits of having multiple lanes is that some of them can be used to carry other types of data in addition to standard USB data. In fact, the USB-C standard defines an Alternate Mode operation where two or four lanes can be dedicated to vendor-specific data. While any vendor can define their own proprietary data stream to send over Alternate Mode, the most common usage of Alternate Mode is to send video signals. And the most common video signal to send is Display Port.

The Display Port video standard was defined by VESA in 2006. It was originally designed as a replacement for VGA, DVI, and HDMI. The biggest difference between Display Port and those other video standards is that Display Port data is packetized. Instead of a stream of analog (in the case of VGA) or digital (in the case of HDMI and DVI) data being constantly sent down the wire with an accompanying clock signal, Display Port breaks the video data into packets and sends those down the wire, very similar to how Ethernet transmits data. Because the USB data standard is also packetized, using Alternate Mode to send Display Port data was an obvious early usage for the Alternate Mode lanes.

Display Port also includes support for digital audio and a few useful display protocols like Display Data Channel (DDC) and Extended Display Identification Data (EDID). DDC provides bi-directional communication between a display and the host. The display reports information like supported resolutions to the host over DDC, and the host controls things like brightness and contrast. EDID is a similar protocol used by the host to determine certain display parameters like supported resolutions. By fully implementing Display Port as an Alternate Mode, USB-C essentially gets audio support, DDC, and EDID capabilities for free.

2.4. Power Delivery 2 vs. 3

There are several versions of the USB-C Power Delivery (PD) specification. The most commonly referenced versions are PD 2 and PD 3. The key improvement in PD 3 is the addition of several optional messages that the host and device can exchange to get more detailed information about each other. There are also some changes in the way power contracts are negotiated.

The key thing to remember is that PD 3 is backward and forward compatible with PD 2. A PD 2 device will work with a PD 3 host, and a PD 2 host will work with a PD 3 device. The only downside to using mismatched hosts and devices is a small delay in the enumeration process. For that reason, it is generally preferable to match the power delivery version of the host and the device, but it is not necessary.

Dawar Technology’s Simple-C driver board uses a PD 3 compliant USB-C controller chip.

3. USB-C Terminology

Before getting into more details on how USB-C works, it’s helpful to understand some of the terms used in the USB-C documentation. One of the more confusing concepts is the different roles a USB product can have. There are three types of roles that a USB product may engage in:

1) USB data source or receiver
2) Power source or receiver (a.k.a., sink)
3) Alternate Mode data (e.g., Display Port) source or receiver

In theory a USB-C product can fill any of the roles above and can change roles while in operation. For example, a product can be providing USB data, receiving power, and receiving Display Port data. To help clarify these roles, certain terms used in the USB specifications are defined below and used throughout this document.

UFP (Upward Facing Port)
A UFP is any USB-C capable product that is receiving data. In other words, its port is looking upstream towards the product that is sending the data. For example, a USB printer is often in the UFP role.

DFP (Downward Facing Port)
A DFP is any USB-C capable product that is sending data. In other words, its USB-C port is looking downstream towards the product that is receiving the data. Typically the DFP is a host computer.

UFP_U (Upward Facing USB Port)
A UFP_U is any USB-C capable product that is receiving USB data. Note that UFP_U is often used interchangeably with UFP.

DFP_U (Downward Facing USB Port)
A DFP_U is any USB-C capable product that is sending USB data. Note that DFP_U is often used interchangeably with DFP.

UFP_D (Upward Facing Display Port)
A UFP_D is any USB-C capable product that is receiving Alternate Mode Display Port data. A USB monitor is a UFP_D.

DFP_D (Downward Facing Display Port)
A DFP_D is any USB-C capable product that is sending Alternate Mode Display Port data. A host computer driving a USB monitor is a DFP_D.

DRP (Dual Role Port)
A DRP is any USB-C product that is capable of switching between being a UFP or DFP in real-time based on what it is connected to and what capabilities its partner can provide.

PDO (Power Delivery Object)
A PDO is a specification of a single voltage and current that a USB-C product can support. For example, every USB-C product must support at least 5 Volts at 3 Amps. That is one PDO. If the product can also support 9 Volts at 3 Amps, that is a second PDO. Different USB-C products support different numbers of PDOs.

Power Source/Provider
A USB-C power source is any product capable of providing power to its partner.

Power Sink/Consumer
A USB-C power sink is any product capable of receiving power from its partner.

A USB-C product can support different combinations of the roles defined above. For example, a UFP can also be a DFP_D and a power sink. That means it is providing USB data to its partner (UFP) while receiving Alternate Mode video and power from its partner (DFP_D and power sink). And if it is configured as a Dual Role Port (DRP), it can change roles at any time. For example, let's say a product is currently a power source. Let's also say that even though its partner is currently acting as a power sink, it is capable of providing power. If the product loses power (i.e., it is unplugged), it could ask its partner to begin providing power. At this point the power roles would swap and current would begin flowing in the opposite direction.

4. Plugs, Receptacles, and Pinouts

One of the best improvements of USB-C is that the plug is symmetrical allowing it to be inserted right side up or right side down. In fact, there actually is no "right side". A symmetrical connector eliminates the try-it-one-direction-then-flip-it-over-and-try-it-then-flip-it-over-again-until-you-get-it-right ritual of plugging in a USB cable. To accomplish this, the USB-C specification added two necessary changes. First, there is a cable orientation detection capability. This is accomplished with the CC pins and will be discussed in section 5. Second, there has to be a multiplexer on the data pins that can swap them so they get connected correctly.

The pinout of a USB-C cable's plug looks like this:

GND	RX2+	RX2-	VBUS	SBU1	D-	D+	CC	VBUS	TX1-	TX1+	GND
GND	TX2+	TX2-	VBUS	VCONN			SBU2	VBUS	RX1-	RX1+	GND

Figure 4: USB-C Cable Pin Out

A brief description of each set of signals is provided below:

Pins	Description
TX1+/-	USB 3 transmit or Alternate Mode lane
TX2+/-	USB 3 transmit or Alternate Mode lane
RX1+/-	USB 3 receive or Alternate Mode lane
RX2+/-	USB 3 receive or Alternate Mode lane
SBU1/2	Alternate Mode lane
D+/D-	USB 2 bi-directional lane
CC/VCONN	PD negotiation and cable power

The cable can be inserted into the receptacle either in the orientation shown above or rotated 180°. The product that the cable gets plugged into must determine the insertion orientation, then set up a multiplexer so that all the pins are connected correctly on the product side. Typically, the USB processor chip determines the orientation and includes a multiplexer to route the signals internally to the correct silicon processing blocks.

The D+/D- lane is dedicated to USB 2 communications and is backward compatible with any USB 2 product. Note that the D+/D- pins are only on one side of the connector. That is done so that the receptacle can have D+/D- pins on both sides. That allows the D+/D- pins to be connected without having to go through a multiplexer.

The TX and RX lanes can be used either for USB 3 communications or they can be used for an Alternate Mode function like Display Port.

The SBU lane is dedicated to Alternate Mode usage.

The CC/VCONN pins are used to determine orientation, handle the PD negotiation, and provide power to active electronics that may be present in the cable. See section 9 for more information on cables.

The VBUS pins are used to provide power to the product. Unlike previous USB products, the voltage on VBUS is negotiated between the two connected products and can go as high as 20 Volts.

Not all USB-C cables include all of these pins. Some cables are for charging only and don't connect the data pins at all. Some cables populate the data pins but don't meet the requirements to support USB 3 speeds. If you're using an off-the-shelf cable, it's important to qualify the cable to your specific requirements.

5. CC/VCONN Pins

The USB-C cable has one pin labeled CC and another pin labeled VCONN (refer to Figure 4). You can see that these pins are in mirrored positions so that when you rotate the cable 180° from the orientation shown in figure 4, the CC pin ends up where the VCONN pin is and vice versa.

Every USB product has a default power role of being a sink or a source. This is defined on the product by either pulling the CC line down to indicate a power sink or pulling it up to indicate a power source. This also defines the default data role (UFP or DFP) because by default a power source is a Downward Facing Port (DFP) and a power sink is an Upward Facing Port (UFP). To switch at run time, the USB-C product must be capable of switching from a pull-up to a pull-down or vice versa. The CC resistors are typically managed by the USB-C chip.

These CC pull-up and pull-down resistors are on both products that the cable connects to. When the cable is first inserted, the products don't know what the cable orientation is yet, so they expose pull-ups or pull-downs on both of the possible CC pin locations. That sets up a resistor divider between the two products on one of the CC pins at each end. By measuring the voltage on both CC pins, each product can determine what the cable orientation is and which CC pin on the product side is connected to the CC pin on the cable.

The values of the resistors used on each end also define how much power a DFP can source and a UFP can sink when operating at 5 Volts. By measuring the voltage on the CC line, the two products can quickly determine the maximum current that can be provided. This is why the VBUS line on a USB-C connection starts at 0V instead of at 5 Volts. Both products measure the CC voltage so they can both determine the maximum allowed power. Once that's known, the DFP sets VBUS to 5 Volts and the UFP limits the amount of current it draws based on the CC pin voltage.

Once each product knows which CC pin to use on their end, the unused CC pin on each end can then be used as a VCONN pin. The VCONN pin is used to provide power to Electronically Marked Cable Assemblies (EMCA). In short, some cables have active components in the cable used to provide information about the cable's specifications like max current, max data rate, etc. To read out that data, the USB-C product has to provide power for the electronics in the cable using the VCONN pin. An EMCA is required for all applications that support USB 3.1 speeds or power delivery greater than 3 Amps. VCONN is also needed for active cables that use a re-driver or other techniques to go longer distances. This is discussed in more detail in section 9.

Once the CC line is established between the two connected products, it is used as a communications channel. A communications protocol called Power Delivery (PD) is used to exchange information between the two products. These messages are used to set up the higher voltage and current options, and the Alternate Mode features. Details of the PD negotiation are discussed in the next section.

6. Power Delivery

By default, the DFP is the power source and the UFP is the power sink. These roles can change during the initial PD negotiation. They can also change at a later point in time. When two USB-C products are first connected, VBUS is 0 Volts. This is done because some USB-C products are capable of providing or sinking high voltages and high currents. To protect both products on initial connection, VBUS starts at 0 Volts. Once both products have measured their respective CC voltages and determined the maximum initial current, the DFP sets VBUS to 5 Volts. The UFP is responsible for limiting the current it draws.

Once this initial 5 Volts contract is established, the two products may begin a negotiation process to increase the voltage and current. This negotiation is accomplished through a series of hand-shaking messages exchanged on the CC line. Each message includes a CRC used to verify that the message was received correctly. The receiver always sends an acknowledgement stating that the received CRC was good. These CRC and acknowledgements are left out of the following steps to keep things simple.

Most PD negotiations follow this basic pattern:

1) The Source tells the Sink what its capabilities are. This includes a list of available Power Delivery Objects (PDOs) and their ratings. PDOs are explained later in this section.
2) The Sink sends a Request Data Object (RDO) to the Source requesting a particular PDO.
3) If the Source can meet the Sink's request, it sends an acceptance message to the Sink.
4) The Sink enters a standby period where it pulls less than 500 milliamps.
5) The Source begins to transition VBUS from 5 Volts to the requested voltage.
6) Once the Sink has detected that VBUS is stable, it tells the Source that it's ready to begin operation at the higher voltage and current.

The Source and Sink store their respective power capabilities in a Power Delivery Object or PDO. The PDO includes information like whether the voltage is fixed or variable, if it supports Dual Role Power (DRP), its peak current, etc. A USB-C chip supports one or more PDOs. The first PDO is always the standard 5 Volts. This is the only PDO that must be supported by a product. Additional PDOs can also be added to support higher voltages and currents.

The following PDO voltages are typical for most USB-C high voltage products:

- 5 Volts at 3 Amps (15 Watts)
- 9 Volts at 3 Amps (27 Watts)
- 15 Volts at 3 Amps (45 Watts)
- 20 Volts at 3 Amps (60 Watts)

Note that even though the USB-C spec states that the maximum current is 5 Amps, that is typically only used for fast chargers for laptops and smartphones. For constant power sourcing, like providing power to a monitor, 3 Amps is typically the max.

Some products only support two PDOs. Some support all four. DRP products have a list of Source PDOs and a separate list of Sink PDOs. Two products that are negotiating a PD contract don't need to support the same number of PDOs. They just have to both support the same one in order to use

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it. For example, one product may have two Source PDOs, one for 5 Volts and one for 20 Volts. The second product may have all four Sink PDOs. In that case, the two products should be able to successfully negotiate a contract for 20 Volts at 3 Amps.

Each USB-C chip has a set of configurable parameters for setting up its PDOs. Here's an example for a Texas Instruments TPS65982 chip:

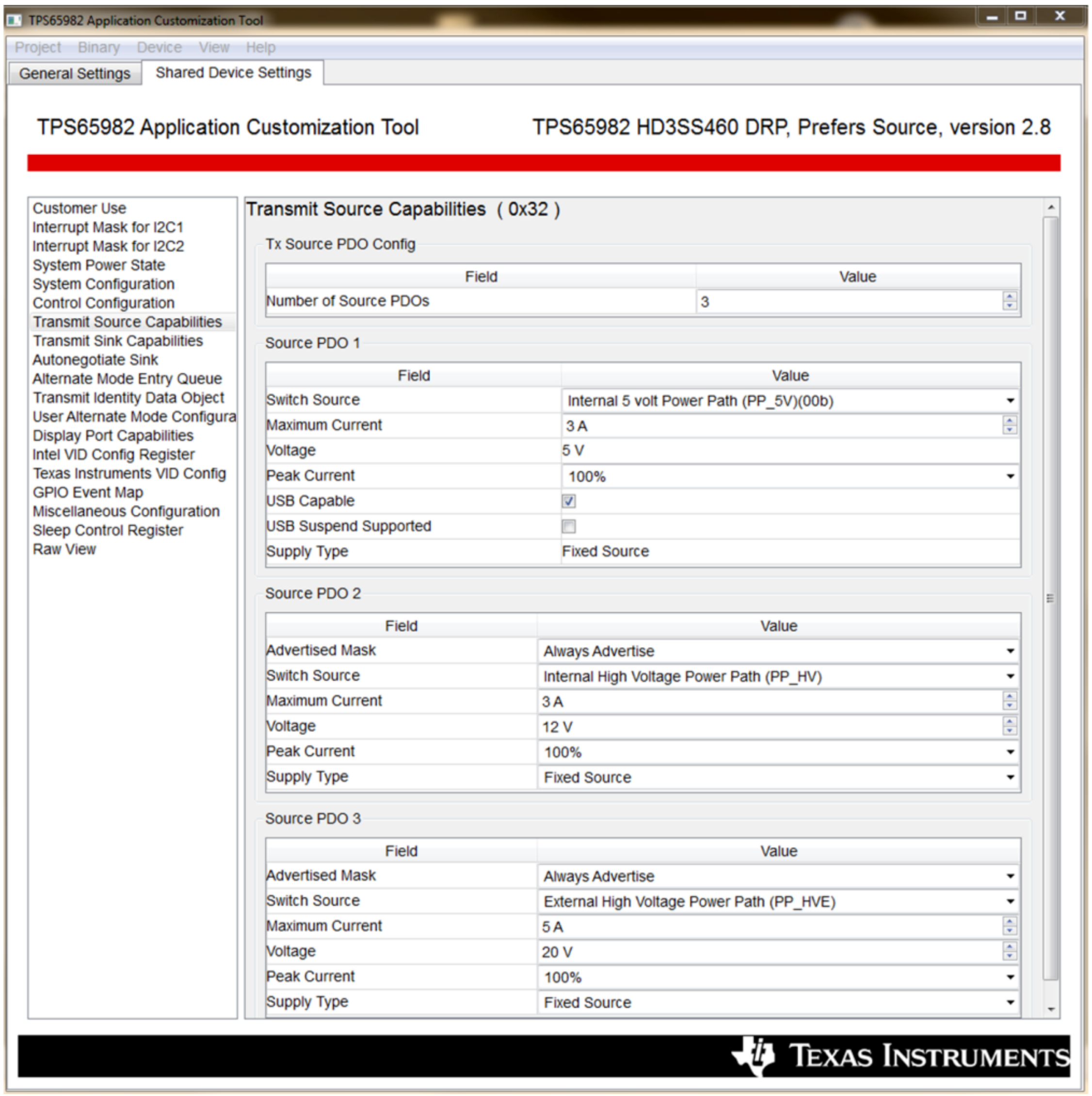

Figure 5: TI TPS65982 PDOs

This chip is currently configured for three Source PDOs. The first is the required 5 Volts. This product supports up to 3 Amps on the required 5 Volts. The second PDO is 12 Volts at 3 Amps, and the third is 20 Volts at 5 Amps. The PDO settings and options are slightly different for each USB-C chip, and there are different options for PD 2 vs. PD 3. You will need to study your chip's documentation carefully to understand how to configure its PDOs.

Most of the time the Sink does not transmit its PDO list to the Source. Instead, the Source sends its list of PDOs and the Sink returns an RDO specifying which PDO it wants. For example, let's say the

Source sends out the PDO list shown above for the TI TPS65982 chip. The Sink wants 12 Volts at 3 Amps, so it returns an RDO specifying PDO number 2.

There are numerous Power Delivery use cases that aren't discussed in this document including variable power supplies, charging power supplies, and swapping roles. These use cases aren't relevant when using the Dawar Simple-C driver board. For more information on these use cases, refer to the resources listed at the end of this document.

7. Alternate Mode Display Port

In addition to negotiating power, the PD protocol can also be used to enable Alternate Mode. In Alternate Mode the SBU, TX1, TX2, RX1, and RX2 lanes can be used to transmit non-USB data. The USB-C specification allows Alternate Mode to be used for any vendor-specific proprietary communications, but there are also several industry-standard uses for Alternate Mode including Display Port over Alternate Mode which is defined and licensed by VESA.

Once the standard PD negotiation is complete and a power contract has been agreed upon by both products, the DFP sends a request to the UFP asking what SVIDs it supports. SVID, which stands for Standard or Vendor ID, is a unique 16-bit number assigned by the USB Implementers Forum (USB-IF) to a company that wants to implement its own Alternate Mode behavior. It's similar to a Vendor ID (VID) that gets assigned to any company that develops a USB product and that is used in conjunction with a Product ID (PID) to uniquely identify a specific type of USB device. In addition to company-specific SVIDs, there are also industry standard SVIDs used for protocols like Display Port over Alternate Mode.

The general sequence of PD messages for enabling Alternate Mode is:

1) The DFP sends a request to the UFP asking what SVIDs it supports.
2) The UFP responds with a list of SVIDs. If it supports Display Port over Alternate Mode, one of the returned SVIDs is 0xFF01.
3) The DFP sends a request to the UFP to enter Display Port mode.
4) The UFP sends an Acknowledgement.
5) The DFP sends a Status request.
6) The DFP sends a DP Configure request.

If all of the messages are correct and all the CRCs are good, then Display Port over Alternate Mode is enabled. At that point the DFP begins to provide Display Port data over one or more of the Alternate Mode lanes. For the purposes of Display Port, the product providing the Display Port data is then referred to as the DFP_D and the product receiving the Display Port data is the UFP_D.

The message flow shown above is just one example. The UFP can send Display Port data up to the DFP while at the same time the DFP is sending USB data down to the UFP. To help differentiate these two sets of roles, the USB documentation introduces the terms DFP_U to refer to a DFP port that is transmitting USB data, and UFP_U to refer to an upward facing port that is receiving USB data. A product can be a UFP_U and a DFP_D at the same time, meaning it is providing USB data to its connected device while receiving Display Port data from the connected device. And as mentioned

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earlier, the power roles are also independent, so the UFP_D might be providing power to the DFP_D or vice versa.

Display Port Alternate Mode can be configured in three ways:

- One lane for USB and two lanes for Display Port
- Two lanes for USB and two lanes for Display Port
- Four lanes for Display Port

Two Display Port lanes support resolutions up to 4K/UHD (3840 x 2160) with a 60 Hz refresh rate. If all four lanes are used, Display Port can go up to 8K/FHD (7680 x 4320) at 60 Hz for one display or two displays at 4K. Part of the UFP_D and DFP_D negotiation is determining how many lanes are needed for the video data being sent and which lanes to use.

If all of this sounds very complicated, the good news is that you don't have to worry about most of this. The messages, responses, and lane negotiation are all handled by the USB-C controller chip. All you have to do is make sure your controller chip is configured correctly. To do that, you need to understand these different roles and their related terminology, but you don't need to worry about the specific bytes sent back and forth between the two products.

8. Audio Signals

Standard Display Port includes the ability to carry audio packets along with video packets. Therefore, this same capability is also supported by Alternate Mode Display Port. Of course, the audio signals have to be encoded with the video signals on the DFP_D side. Once the Display Port signal reaches the UFP_D, the audio must be separated back out, converted to analog signals, and delivered to the speakers. Some USB-C controller chips will manage the audio separation and decoding process and provide the analog audio outputs along with video outputs (like LVDS). Other USB-C controllers just output the Display Port signal which then has to be processed by additional chips.

USB-C also supports a direct channel analog audio mode. In this mode, the D+ and D- pins are retasked as audio left and right respectively. This is typically used to provide direct support for analog headphones using a USB-C-to-audio-jack adapter for a smartphone or tablet. This audio mode is rarely if ever used when connecting a DFP to a UFP.

9. Circuit Protection

The small size of the USB-C connector combined with the large number of pins increases the risk of pin-to-pin shorts caused by twisting the cable, pulling it out at an angle, or debris between the pins. Since the connector could be drawing up to 100 Watts, it is very important to provide proper protection around the USB-C connector. Damage could also be caused by products that don't meet the USB-C standard. For example, a product might set VBUS to 20 Volts before the PD negotiation is finished. Or a cable might not be capable of handling the higher current some products can draw.

Fortunately, several companies have developed circuit protection devices specifically designed for USB-C. For example, the Texas Instruments TPD8S300 suppression IC provides overvoltage protection for CC and SBU pins up to 24 Volts. It also provides ESD protection for CC, SBU, and D+/D- pins. STMicro's TCPP01-M12 provides ESD protection and overvoltage protection up to 22 Volts on the CC lines. The STMicro part doesn't protect as many lines as the TI part, but it's smaller and less expensive. Some companies have included overvoltage and ESD protection directly in the USB-C controller chip. For example, the Cypress CCG3 family of chips includes ESD protection for the CC, SBU, D+/D-, and VBUS pins. They also have built-in overvoltage protection.

For more information on USB-C circuit protection refer to the Texas Instruments guide "Circuit Protection for USB Type-C". It provides an excellent overview of the kinds of problems that can arise with USB-C and how to prevent them with a combination of individual components and integrated solutions.

10. Cables

The USB-C specification defines three types of USB-C cables:

1. Full-featured USB-C to USB-C cable that supports USB 2.0 and USB 3.1 data operations and Alternate Mode.
2. USB-C to USB-C cable that supports USB 2.0 only.
3. Captive cables with either a full-featured USB-C or USB 2.0 at one end.

Some cables include a small chip that defines the capabilities of the cable. These are called Electronically Marked Cable Assemblies or EMCAs. As mentioned earlier, typically the VCONN pin provides power to the electronics in the cable. A cable that supports currents greater than 3 Amps or that supports Alternate Mode must be an EMCA.

An EMCA can be classified as passive or active. A passive EMCA does not alter the signals that pass through it. An active EMCA provides signal conditioning and re-drivers which can greatly increase the functional length of the cable. The maximum length of a passive EMCA capable of supporting USB 3 speeds of 5GHz is around 2 meters (6.5 feet). An active EMCA can be much longer. Some vendors make optically isolated EMCAs which can be 15 to 30 meters (50 to 100 feet) long.

Note that the VCONN wire cannot be directly connected at both ends of an EMCA. There either has to be two separate controller chips, one at each end of the cable and each driven off their respective VCONN pins, or there is a single chip that is connected to both VCONN pins. In the case of a single controller chip, the chip must be capable of being powered by either VCONN pin while electrically isolating the two pins from each other.

There are several USB-C chips specifically designed for EMCAs. One example is the Cypress CCG2 chip. The chip is typically located just behind the plug in the cable housing:

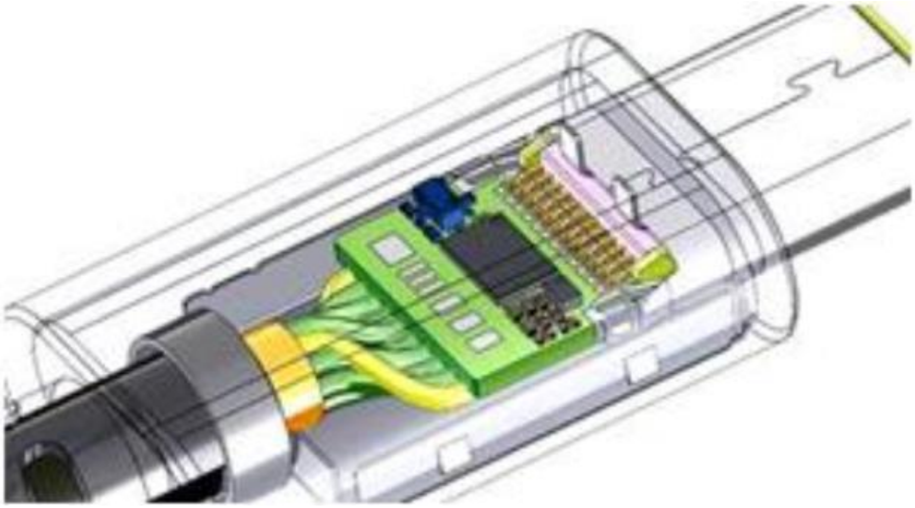

Figure 6: EMCA

The purpose of the chip is to provide the DFP with the following cable characteristics:

- Max VBUS current
- Cable length
- Type of EMCA (passive or active)
- Types of connectors on both ends of a cable (Type-C to Type-C, Type-C to Type-A, etc.)
- Number of cable controllers in the cable (1 or 2)
- Type of USB signaling (USB 2.0, USB 3.1 Gen 1 or USB 3.1 Gen 2)
- Vendor ID (16-bit ID that identifies the EMCA manufacturer)
- Product ID (16-bit ID that identifies the EMCA product)
- Support for Alternate Modes (e.g., DisplayPort, PCIe)
- Support for vendor-specific protocols (e.g., vendor-specific docking protocol)

This information is only read by the DFP. It is the DFP's responsibility to ensure that the cable meets the application's requirements. For example, if the DFP supports Alternate Mode Display Port but the cable does not, then the DFP should not provide the Display Port SVID to the UFP.

For more information on EMCA refer to the Cypress app note "Designing USB 3.1 Type-C Cables Using EZ-PD™ CCG2".

11. Resources

Cypress (a.k.a., Infineon) has a lengthy introduction to USB-C video that covers most of the topics mentioned in this paper. Cypress has also produced a set of 5 video tutorials on USB-C that describe some of the Infineon eval kits and development tools.

DigiKey hosted an excellent USB-C webinar led by STMicroelectronics and Würth Electronics. The first half provides some background and a general overview of USB-C. The second half dives into circuit protection devices and shows some real-world testing results.

The following white papers are excellent resources for additional information on USB-C:

General Information on USB-C

Microchip AN1953: Introduction to USB Type-C™

Infineon: Hardware Design Guidelines for DRP Applications Using EZ-PD USB Type-C Controllers

USB-C Power Delivery

Texas Instruments: A primer on USB Type-C® and USB Power Delivery Applications and Requirements

Texas Instruments: USB PD Power Negotiations

Alternate Mode

Texas Instruments: Alternate Mode for USB Type-C™: Going beyond USB

Texas Instruments: PD Alternate Mode: DisplayPort

Circuit Protection

Texas Instruments: Circuit Protection for USB Type-C™

Electronic Design: Prioritize Circuit Protection for USB Type-C Interfaces

Cables

Infineon: Designing USB 3.1 Type-C Cables Using EZ-PD™ CCG2

Revision History

Rev A February 16, 2022	Initial Release
Rev B June 8, 2022	Corrected picture labels in §2.1 Reversible 24 Pin Connector.

THINKING BEYOND THE TOUCH
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