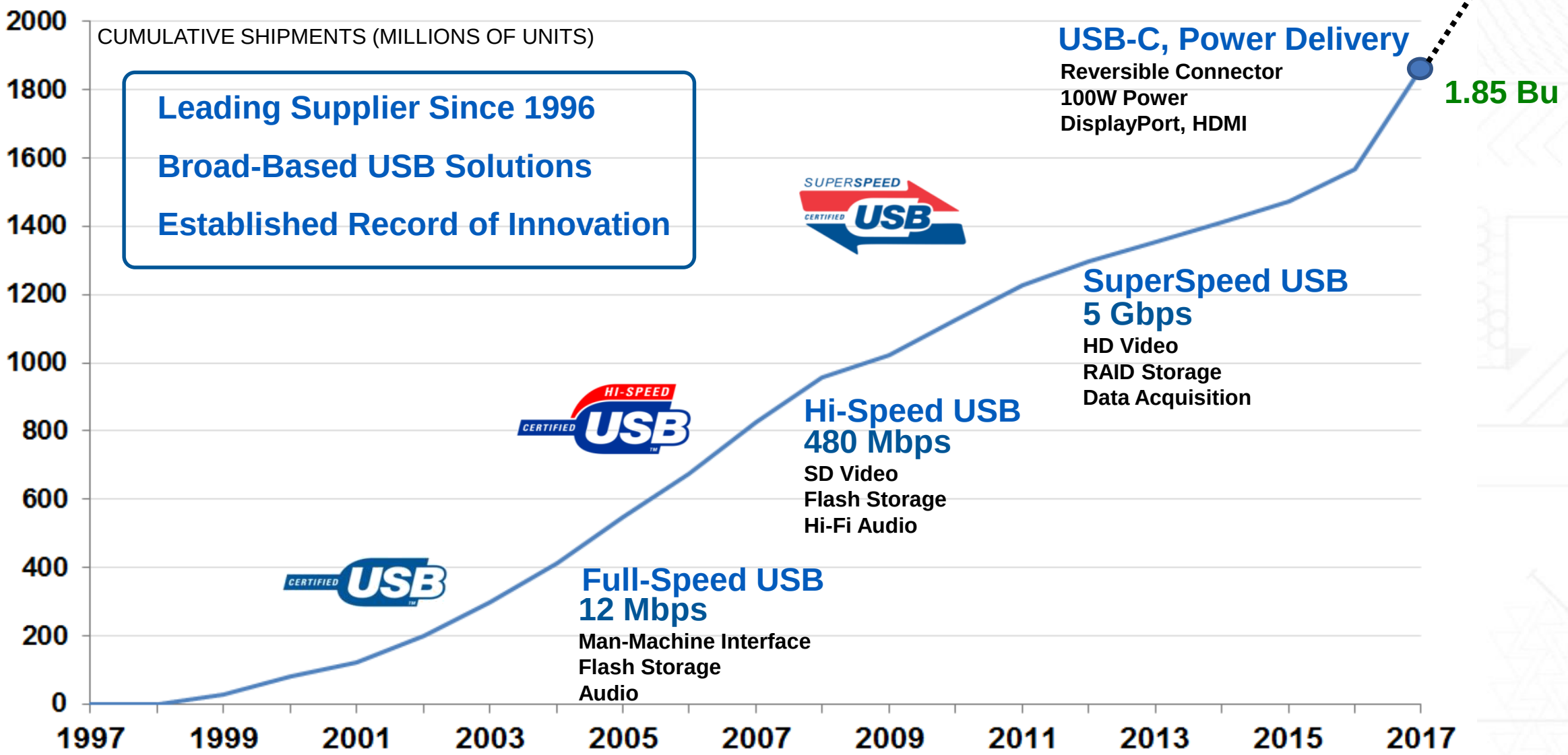
USB-C EMCA Cable and Power Adapter Application Solutions

Q418

Making USB Universal™ Since 1996



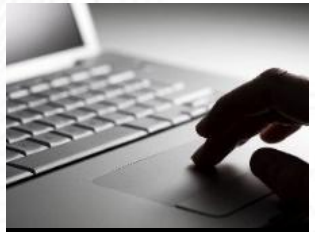
CYPRESS
EMBEDDED IN TOMORROW™

Cypress Is #1 In USB-C with 37%* Market Share

First-To-Market, Customer-Proven, Innovation Pace Setter

Over 10 Billion USB Ports, All Will Transition to USB-C

2017-2022 TAM[1] Growth: 40%


Computing


Gaming


Smart Home


Automotive


Medical


Mobile

HD Video/Audio


Communications


Industrial


Everywhere

2015 2016 2017 2018 2019 2020 2021

Cypress USB-C Innovations

First USB PD Controller to Market	First EMCA Smallest USB PD Controller	First USB PD + Billboard Controller	First Dual-Port USB PD Controller	First PD 3.0 PPS Controller	First Integrated USB PD Hub	First HDMI Alternate Mode Controller	First to Achieve QC 4.0 & PPS Certification
OCT'14	MAR'15	DEC'15	JAN'16	JUN'16	AUG'16	JAN'17	NOV'17
							

Cypress USB-C Leadership:

- Five generations of market-proven solutions accelerate customer's time-to-Production
- Programmability keeps pace with standard changes
- Mature design tools empowers a broad customer base
- Worldwide customer training workshops proliferate best design practices

[1]Data Source: Gartner 2017, IHS 2016 and Cypress estimates
*Cypress estimation

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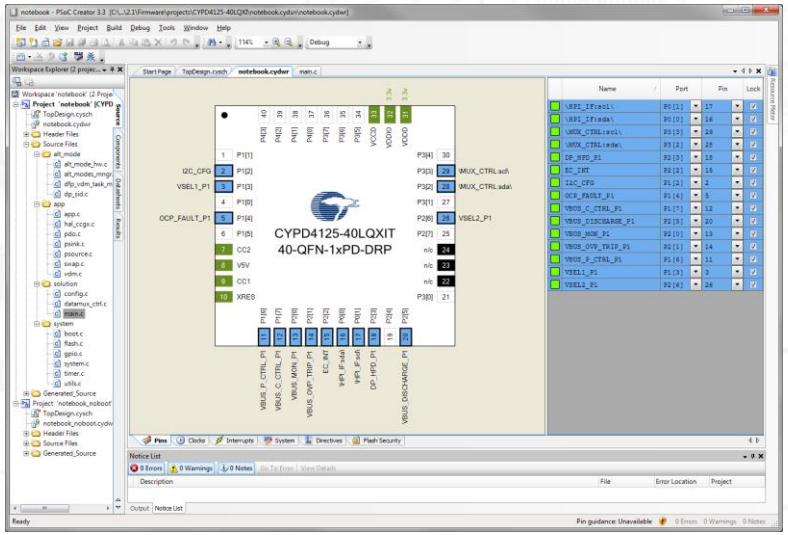
Cypress USB-C Portfolio

EZ-PD™ Programmable USB-C and Power Delivery Solutions

Solutions For Any USB-C Application

EZ-PD Config. GUI & PSoC Creator IDE



All-In-One Dev Kits & Reference Designs

EZ-PD Solution Families

CCG1
General Purpose

CCG2
Automotive, Cable, Dongle, Mobile

CCG3
Automotive, Camera, Gaming, General Purpose, Power adapter

CCG4
Desktop, Laptop, PC Peripheral, Server, Tablet

CCG3PA
Automotive, Power Adapter, Power Bank, Power outlet

CCG5
Dock, TBT PC

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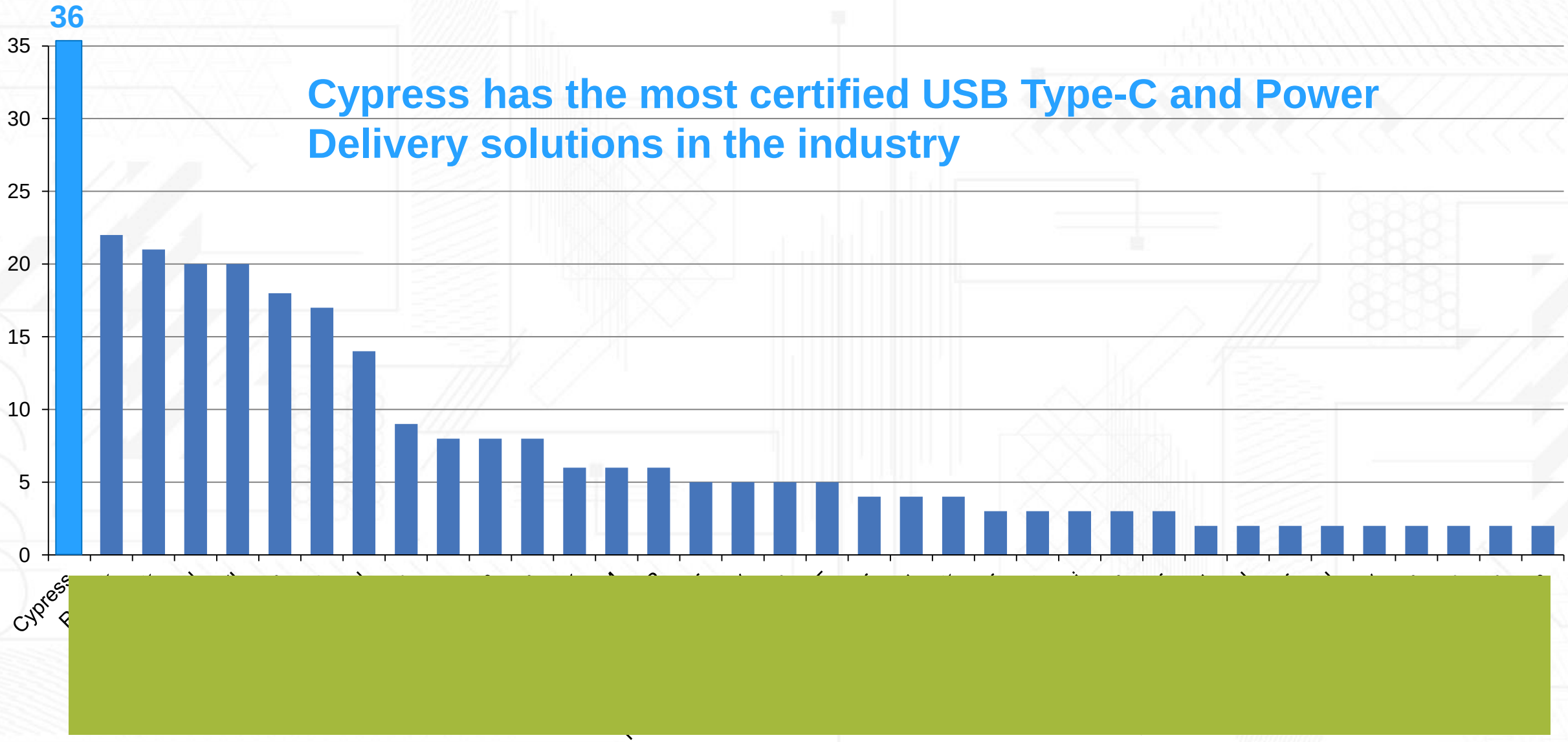
Cypress Leads USB-IF Certification



Certified EZ-PD Applications

EZ-PD Product	Part Number	Test ID (TID)	Application	Function	Date
CCG1	CYPD1103	1095059	Cable	EMCA	5/22/2015
	CYPD1120	1096044	Dongle	UFP	8/14/2015
	CYPD1122	1096037	Notebook	DRP	8/14/2015
	CYPD1132	1096040	Power Adapter	DFP	8/14/2015
	CYPD1134	1096042	Notebook, Desktop	DFP	8/14/2015
CCG2	CYPD2103	1095054	Cable	EMCA	5/22/2015
	CYPD2122	1096039	Tablet	DRP	8/14/2015
	CYPD2134	1096047	Power Adapter	DFP	8/14/2015
	CYPD2120	1097040	Dongle	UFP	11/25/2015
	CYPD2121	1097041	Monitor, Dock	DRP	11/25/2015
	CYPD2125	1097045	Monitor, Dock	DFP	11/25/2015
CCG2 Automotive	CYPD2194	1060084	Charger Port	DFP	12/8/2017
CCG3	CYPD3105	1098018	Thunderbolt Cable	EMCA	2/12/2016
	CYPD3120	1000061	Dongle	EMCA	8/5/2016
	CYPD3121	1010055	Power Bank	UFP	11/23/2016
	CYPD3123	1098119	Dongle	DRP	2/6/2018
	CYPD3125	1098019	Notebook, Phone	DRP	2/12/2016
	CYPD3135	1099031	Power Adapter	DFP	5/13/2016
CCG4	CYPD4126	1090040	Notebook, Desktop	DRP	7/12/2018
	CYPD4136	1090044	Notebook, Desktop	DRP	7/12/2018
	CYPD4225	1098024	Notebook, Desktop	DRP	2/12/2016

Certified EZ-PD Applications (cont.)

EZ-PD Product	Part Number	Test ID (TID)	Application	Function	Date
CCG4M	CYPD4255	1099030	Notebook, Desktop	DRP	5/13/2016
CCG5	CYPD5125	1071049	Notebook, Desktop	DRP	3/21/2018
	CYPD5225	1030056, 1070049, 1080040	Notebook, Desktop	DRP	5/24/2017, 2/16/2018
	CYPD5235	1072049	Dock (Upstream port)	DRP	4/19/2018
	CYPD5236	1073049	Dock (Downstream port)	DRP	4/19/2018
CCG3PA	CYPD3171	1040045	Power Bank	DRP	9/15/2017
	CYPD3174	1050039	Opto-coupler based Adapter	DFP	9/15/2017
	CYPD3174	1060036	Opto-coupler based Adapter (PPS)	DFP	1/10/2018
	CYPD3175	1040032	Direct feedback-based Adapter	DFP	9/15/2017
	CYPD3175	1060037	Direct feedback-based Adapter (PPS)	DFP	1/10/2018
CCG5C	CYPD5126	1101032	Notebook, Desktop	DRP	8/31/2018
CCG6	CYPD6125	1100033	Notebook, Desktop	DRP	8/31/2018
CMG1	CYPD2703	1000177	PD 3.0 Cable	EMCA	6/28/2018
	CYPD2704	1000178	PD 3.0 Cable	EMCA	6/28/2018
CCG3PA Auto	CYPD3196	24	Auto Car charger	DFP	10/08/2018

Certified Customer Products with Cypress CCG3PA

Customer/ Partner	Part Number	Test ID (TID)	Application	Wattage	Date
[redacted]	CYPD3175-24LQXQ	1080029	PD3.0 + PPS Car Charger	27W	4/27/2018
	CYPD3174-24LQXQ	1080032	PD3.0 + PPS Wall Charger	27W	4/27/2018
	CYPD3174-24LQXQ	1080026	PD3.0 + PPS Wall Charger	27W	4/27/2018
	CYPD3175-24LQXQ	1080022	PD3.0 + PPS Car Charger	45W	4/27/2018
	CYPD3175-24LQXQ	1080020	PD3.0 + PPS Wall Charger	27W	4/27/2018
	CYPD3174-24LQXQ	1080062	PD3.0 Wall Charger	18W	4/27/2018
	CYPD3175-24LQXQ	1080028	PD3.0 Charging Station	35W	4/27/2018
	CYPD3174-16SXQ	1080053	PD3.0 + PPS Wall Charger	27W	4/27/2018
	CYPD3171-24LQXQ	1080006	PD3.0 Power Bank	18W	4/27/2018
	CYPD3174-24LQXQ	1080011	PD3.0 + PPS Wall Charger	27W	4/27/2018
	CYPD3174-24LQXQ	1090049	PD3.0 Wall Charger	36W	7/12/2018
	CYPD3174-24LQXQ	1090071	PD3.0 Charging Station	60W	7/12/2018
	CYPD3174-24LQXQ	1090050	PD3.0 Car Charger	36W	7/12/2018

Certified Customer Products with Cypress CCG3PA (cont.)

Customer/ Partner	Part Number	Test ID (TID)	Application	Wattage	Date
[redacted]	CYPD3174-24LQXQ	1090018	PD3.0 + PPS Travel Charger	27W	7/12/2018
	CYPD3171-24LQXQ	1090019	PD3.0 Power Bank	45W	7/12/2018
	CYPD3174-24LQXQ	1100028	PD3.0 + PPS Wall Charger	18W	8/31/2018
	CYPD3174-24LQXQ	1100030	PD3.0 + PPS Car Charger	47W	8/31/2018
	CYPD3174-24LQXQ	1100018	PD3.0 Travel Charger	84W	8/31/2018

Cypress USB-C Solutions Are Trusted by Leading OEMs/ODMs

Computing

Mobile

Consumer & Enterprise

Cables and Adapters

USB Portfolio

	Device	Hub	Bridge	Storage	Type-C	
USB 3.1	**CYUSB301x** **FX3** 32-Bit Bus to USB 3.1 Gen 1 ARM9, 512KB RAM	**CYUSB33xx** **HX3** USB 3.1 Gen 1, Shared Link™[1] BC 1.2[2], Ghost Charge™[3]	**CYUSB306x** **CX3** CSI-2[4] to USB 3.1 Gen 1 4 CSI-2[4] Lanes, 1 Gbps/Lane	**CYUSB303x** **FX3S** 16-Bit Bus to USB 3.1 Gen 1 RAID[5], Dual SDXC[6]/eMMC[7]	**CYPD1xxx** **CCG1** USB Type-C Port Controller 1 PD Port, 5 Profiles, 100 W	**CYPD317x** **CCG3PA** USB Type-C Port Controller 30V, PPS, QC4, 64KB Flash
	FX3Gen2 USB 3.1 Gen 2 Peripheral Controller **Contact Sales**	**CYUSB333x** **HX3C** 4 Ports: 1 Type-C, 3 Type-A USB PD, Billboard, BC1.2[2]	**CYUSB361x** **GX3** USB 3.1 Gen 1 to GigE Energy Efficient Ethernet	**CYUSB302x** **SD3** USB 3.1 Gen 1 SD Reader SDXC[6]/eMMC[7], RAID[5]	**CYPD2xxx** **CCG2** USB Type-C Cable Controller 1 PD Port, Termination, ESD	**CYPDC118x** **CCG3PA2** USB Type-C Port Controller 30V, PPS, QC4, 128KB Flash
		NEW **CYUSB43xx** Q119 **HX3PD** USB 3.1 Gen 2 Type-C Hub 7 Ports, PD, Billboard, 10 Gbps			**CYPD3xxx** **CCG3** USB Type-C Port Controller 20-V, Crypto, Billboard	NEW **CYPD27xx** Q418 **CMG1** USB Type-C EMCA Controller PD 3.0, V_{BUS} short protection
USB 2.0	**CY7C6801x/53** **FX2LP** 16-Bit Bus to USB 2.0 8051, 16KB RAM	**CY7C656x4** **HX2VL** 4 Ports 4 Transaction Translators	**CY7C6803x/3xx** **NX2LP/AT2LP** NAND Flash/PATA to USB 2.0 8051	**CYWB0x2xABS** **Arroyo™, Astoria™** 16-Bit Bus to USB 2.0 8051, Dual SD/eMMC[7]	**CYPD4xxx** **CCG4/CCG4M** USB Type-C Port Controller 2 PD Ports,128KB Flash, Mux	NEW **CCG6** Q119 USB Type-C Port Controller 1 PD Port, 128KB Flash, TBT **Contact Sales**
	CYUSB201x **FX2G2** 32-Bit Bus to USB 2.0 ARM9 512KB RAM	**CY7C656x1** **HX2LP** 4 Ports, Industrial Grade 1 Transaction Translator		**CYWB016xBB** **Bay™** HS USB OTG Dual SDXC[6]/eMMC[7]	**CYPD5xxx** **CCG5/CCG5C** USB Type-C Port Controller 2 PD Ports, 25V CC/SBU	NEW **CYPD612x** Q418 **CCG6F** USB Type-C Port Controller 1 PD Port, Load S/W FET, TBT
				Host		NEW **CYPD3177** Q119 **BCR** USB Type-C UFP Controller 5 PDOs, V_{BUS} short protection
USB 1.1	**CY7C638xx/64215/643xx** **enCoRe™ II/III/V** M8C MCU, GPIOs SPI, Flash		**CY7C6521x** **USB-Serial** UART/SPI/I²C to USB 2 Channels, CapSense®	**SL811HS** FS USB Host/Device 256Byte RAM		NEW **CYPAS1xx** Q119 **PAG1S** Secondary-side Controller 1 PD Port, SR, PWM, PPS
	CY7C65210/7 **USB Billboard** ARM Cortex M0 1 or 2 UART/SPI/I²C channels		**CY7C65213** **USB-to-UART (Gen 2)** 3 Mbps, 8 GPIOs	**CY7C67300/200** **EZ-Host/EZ-OTG™** 4/2 Ports, FS USB OTG GPIOs		NEW **CYPAP1xx** Q119 **PAG1P** Primary-side Start-up Controller 90 – 264V

[1] Simultaneous USB 2.0 and SuperSpeed traffic on the same port
[2] Battery Charging specification v1.2
[3] Enables USB charging without host connection
[4] Camera Serial Interface v2.0
[5] Redundant array of independent disks
[6] SD extended capacity
[7] Embedded Multimedia Card

	Concept	Development	Sampling	Production
Status				
Availability			QQYY	QQYY

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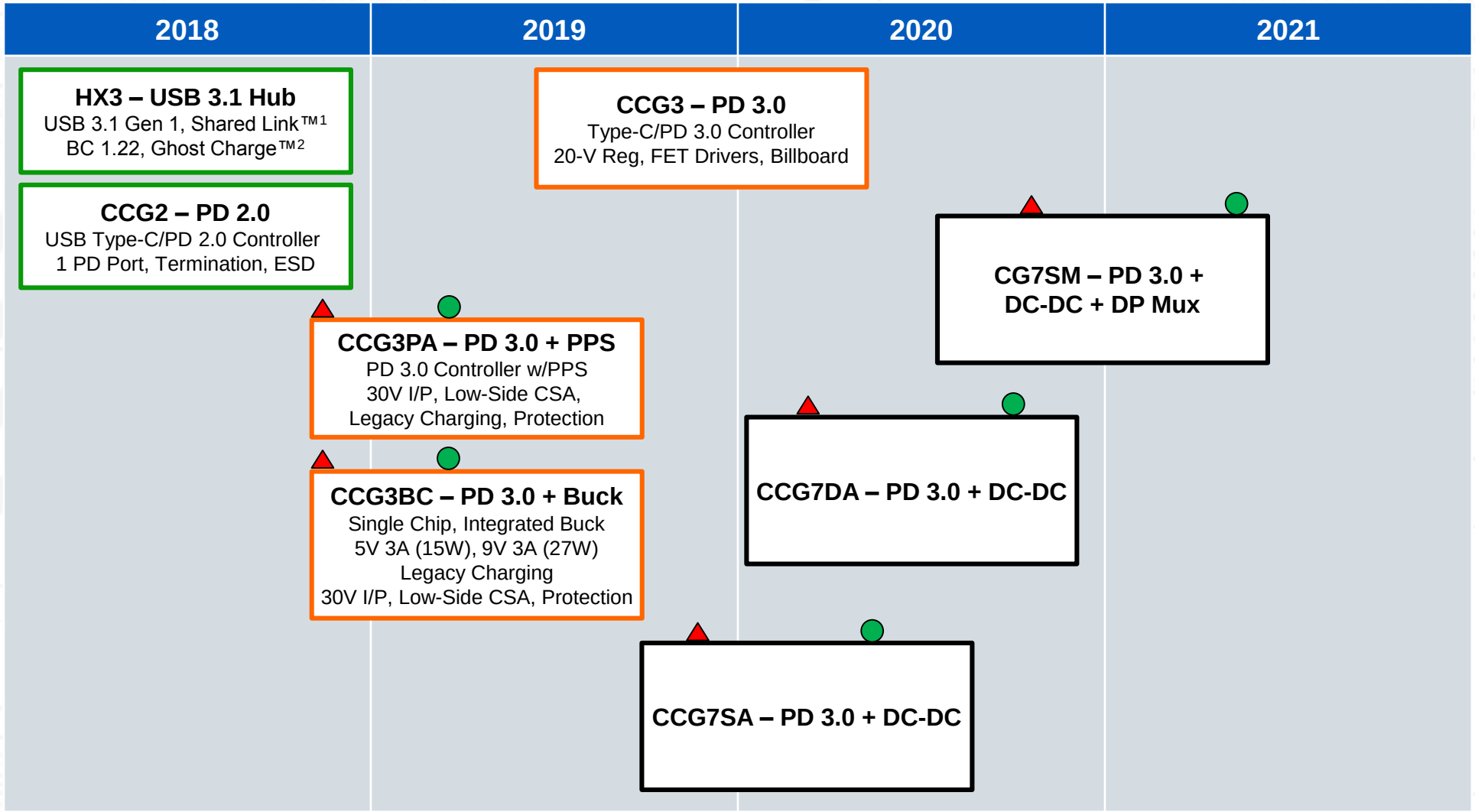
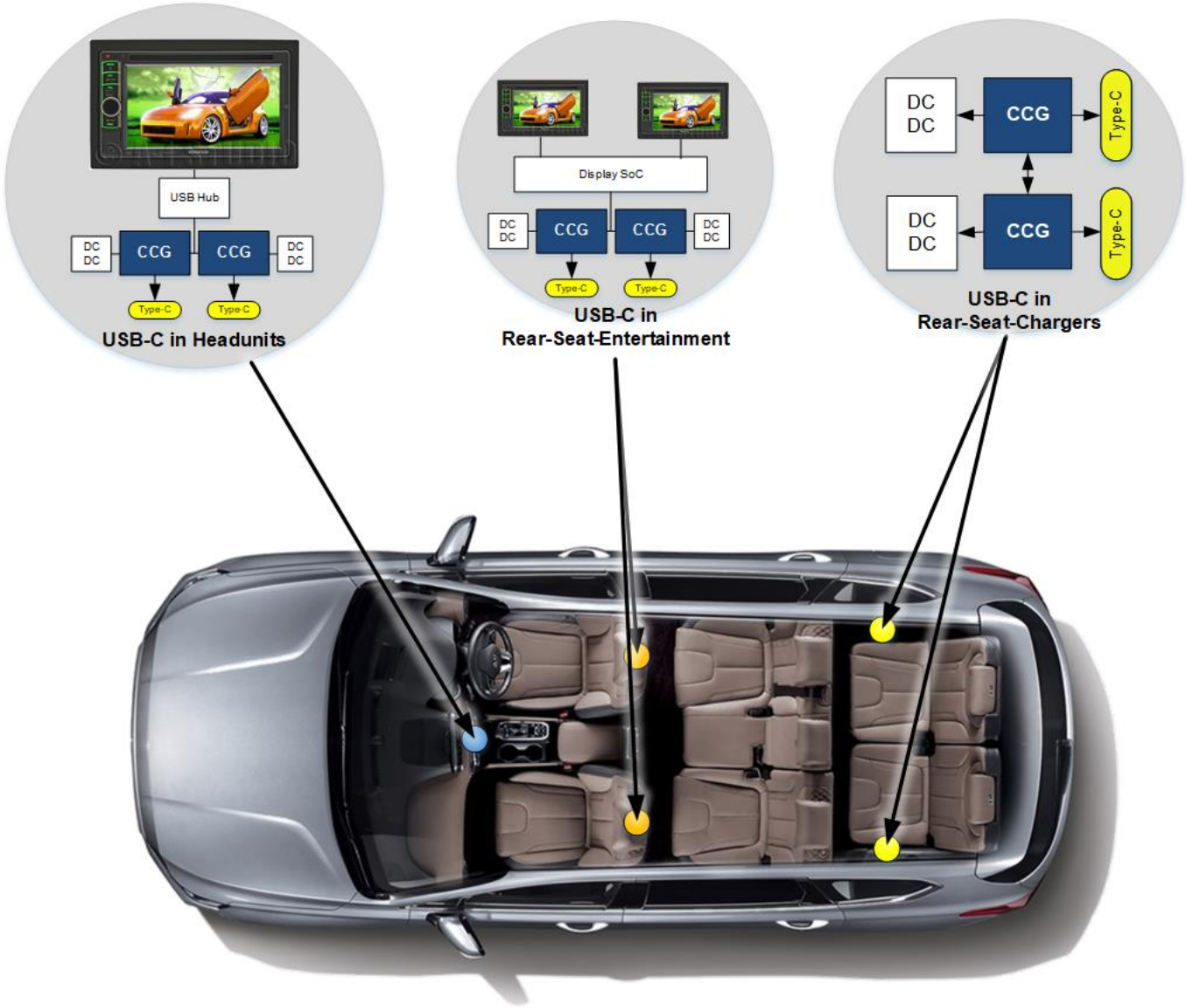
USB Auto Portfolio



USB-C and Power Delivery in Automotive



- Head Units:
  - Interface to multi-Media Hubs
  - Cable compensation for pig-tail cables
- Rear-Seat Entertainment Systems:
  - Support Alternate Mode functionality
  - Implement USB Billboard Device Class
- Rear-Seat Chargers:
  - Standalone Operation
  - Load-Sharing and Thermal Sensing
- **Programmable PD Controller:**
  - Highly Integrated Standalone Controller
  - Single-chip solution for Type-C and Type-A
  - Dynamic Load Sharing between ports
  - Dynamic Cable Compensation
  - Temperature-based power throttling
  - Interface to Multi-Media USB Hubs
  - Alternate Mode support for rear seat systems
  - Support for Legacy Charging Standards
  - Flash upgradability

CYPRESS EMBEDDED IN TOMORROW™

EZ-PD USB-C CMG1

CMG1 = Cable Marker Gen1

CMG1 Delivers a Cost-Effective Solution With V_{BUS} Short Protection for USB-C EMCA

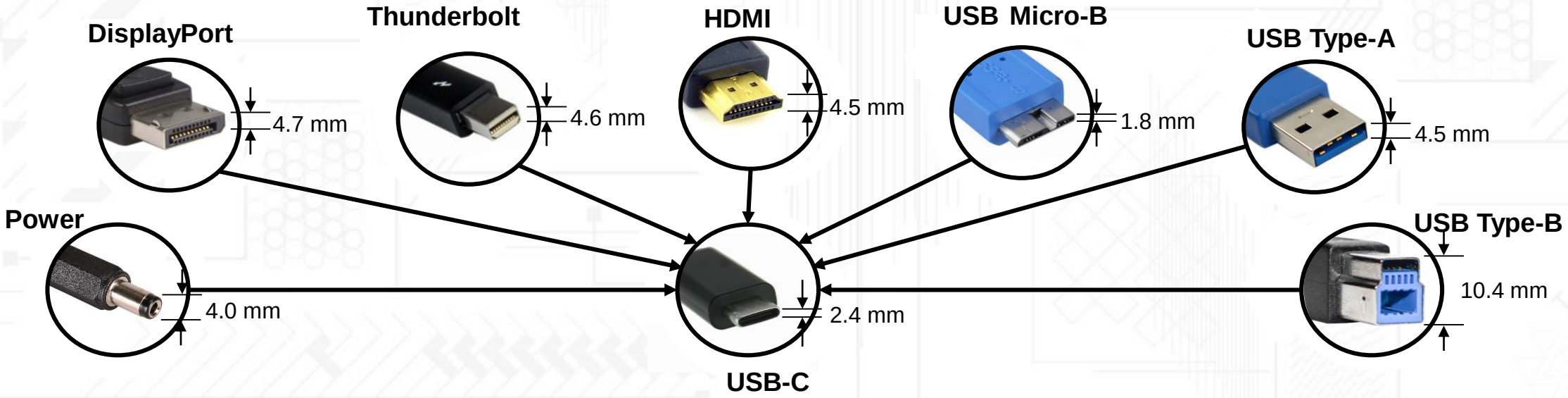
Statement of Objectives

- **Ensure that customers understand the following:**
  - CMG1 is a dedicated USB-C1 electronically marked cable assembly (EMCA)[2] controller for USB-C passive cables
  - CMG1 integrates a USB-C transceiver[3], V_{BUS}[4]-to-configuration channel (CC)[5] short protection, V_{BUS}-to-V_{CONN}[6] short protection, and electrostatic discharge (ESD) protection
  - CMG1 supports Power Delivery (PD) 3.0 and USB Type-C 1.3 specifications' V_{CONN} requirement (3.0–5.5 V)
  - CMG1 offers 32 bytes of storage for vendor- and cable-specific configuration data
- **Simple, declarative statement:**
  - CMG1 is a USB-C EMCA controller that supports PD 3.0, USB Type-C 1.3 and integrates V_{BUS}-to-CC and V_{BUS}-to-V_{CONN} short protection
- **Non-ToA Concepts:**
  - **CMG1**: A single-chip USB-C controller for EMCA passive cables (What we sell)
  - **Multiple discrete components**: Buck-boost regulator, V_{BUS}-to-CC and V_{BUS}-to-V_{CONN} short protection, and ESD protection (What our competitors sell)
  - **An integrated Type-C solution**: A single-chip USB-C solution that supports the latest PD and Type-C standards and offers 32-byte storage for vendor- and cable-specific configuration data (What customers want)

[1] A new standard with a slimmer and reversible USB plug, a reversible cable, protocol support and 100-W PD
[2] A USB cable with an IC that reports cable characteristics (e.g., current rating) to the Type-C ports
[3] A combined transmitter and receiver
[4] USB-C bus wire used for system power, 5–20 V on 100-W USB-PD systems
[5] USB-C bus wire used to carry the PD protocol signals
[6] USB Type-C bus wire used to power the controller in the EMCA

USB-C: Single-Wired Connector

- **USB-C* is the new USB-IF[1] standard that enables:**
  - Slim industrial design with a 2.4-mm plug height
  - Reversible plug orientation and cable direction
  - Transport of USB data along with either DisplayPort, HDMI or Thunderbolt signals on the same connector
  - Easy implementation of low-cost power delivery (PD) up to 100 W



USB-C is the new, slimmer, all-in-one, 100-W connector

*Linked terms are defined in the Glossary

[1] The USB Implementers Forum creates and maintains USB specifications

USB-C Controllers: $1.35B Market by 2022

- **The USB-C controller market is projected to grow from $459M in 2017 to $1.35B in 2022 at a CAGR[1] of 24%**
  - The USB-C port is universal: it is slimmer, reversible, handles multiple protocols, and supports up to 100-W PD
  - Every PD-capable, multiple-protocol USB-C port requires a dedicated controller
- **This fast-growing market requires a USB-IF certified solution that:**
  - Marks cables electronically (EMCA) with a controller IC embedded in the cable plug to report the cable's characteristics
  - Multiplexes USB signals with Thunderbolt, HDMI, or DisplayPort signals on the same connector
  - Supports all PD profiles[2] up to 100 W, for notebooks, tablets, monitors, USB cables, and power adapters
- **Cypress has been a leading supplier in every generation of USB technology: USB 1.1/2.0/3.0 and USB PD**

Cypress CCGx Design Wins

Eliteone All-In-One PC by HP


Elitebook Notebook PC by HP


Elitedesk Desktop PC by HP


USB-C Cable by Belkin


Type-C to HDMI Dongle by Lenovo

Accelerate your USB-C design with Cypress' CCGx Type-C port controllers

[1] Gartner 2015 and Cypress estimates
[2] A USB-IF specified combination of voltage and current ratings that define the power provided

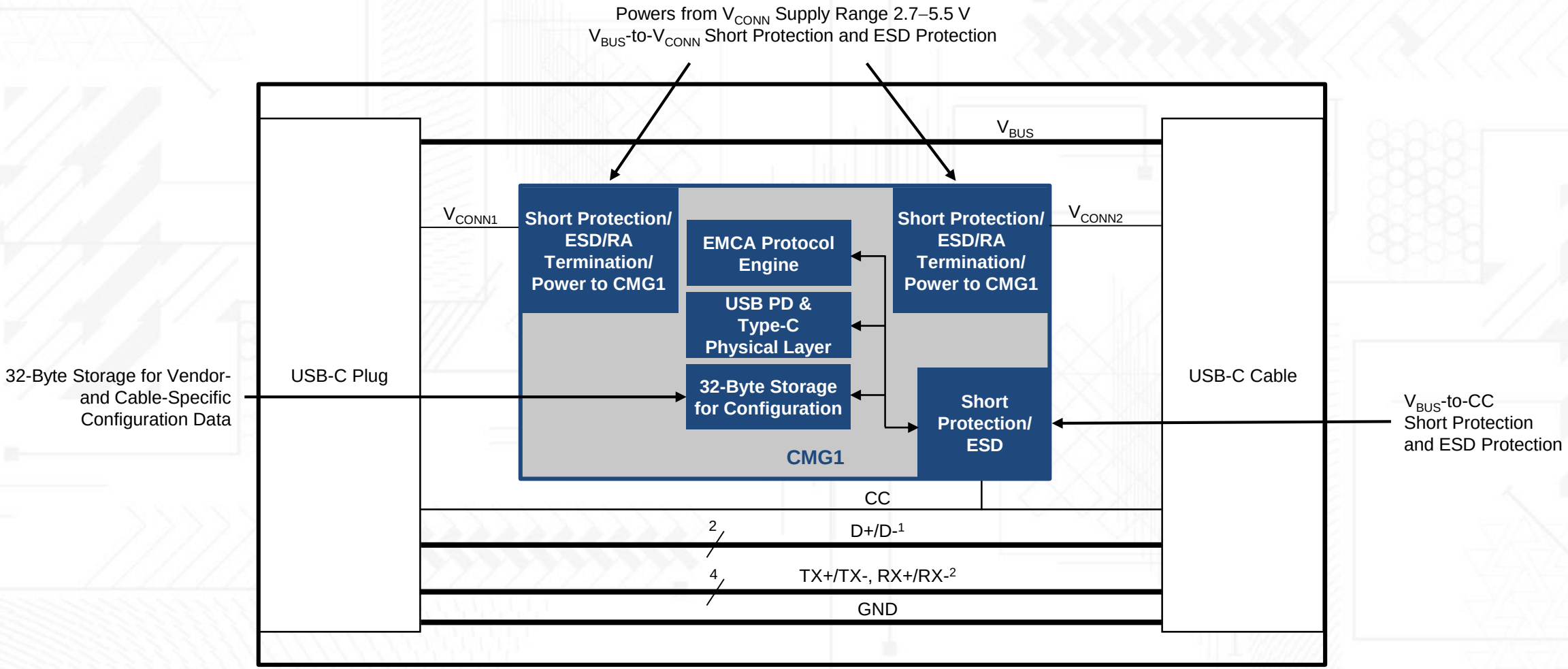
Design Problems Engineers Face

- **Integrating latest power delivery specifications and USB connectors can be complex**
  - Existing controllers for EMCAs do not support latest USB PD 3.0 and Type-C 1.3 specification
- **USB Type-C 1.3 specification requires a V_{CONN} operation range of 3.0–5.5 V**
  - Need to power the USB-C cable with a single-cell, battery-operated system without voltage boost
- **Existing EMCA solutions require large cable assemblies**
  - Additional BOM is required to provide V_{BUS}-to-CC and V_{BUS}-to-V_{CONN} short protection and electrostatic discharge (ESD), creating a larger footprint
- **Cypress' CMG1 solves these problems, providing:**
  - A low-cost, integrated USB-C transceiver with both USB PD 3.0 and Type-C 1.3 specification support
  - Operation from 2.7–5.5-V V_{CONN} supply range
  - Small footprint (9-ball WLCSP package) with V_{BUS}-to-CC and V_{BUS}-to-V_{CONN} short and ESD protection

Cypress' CMG1 is a cost-effective, small-footprint, fully compliant USB-C EMCA solution that reduces BOM

CMG1 Simplifies EMCA System Design with BOM Integration

USB-C EMCA Paddle Card Block Diagram Using CMG1



[1] USB Type-C bus wires used to transmit and receive USB 2.0 data
[2] USB Type-C bus wires used to transmit and receive USB 3.0 and PCIe or DisplayPort data

Fit Questions

- **Do your customers fit any of the following criteria?**
  - Do they design products that could benefit from combining power and USB connectors into a single connector?
  - Do they design USB-C EMCA cables that need to support PD 3.0 and USB Type-C 1.3
  - Do they design USB-C EMCA cables that need to support V_{CONN} requirement of 3.0–5.5-V?
  - Do they design USB-C EMCA cables that need V_{BUS}-to-CC short protection?
  - Do they design USB-C EMCA cables that need V_{BUS}-to-V_{CONN} short protection?

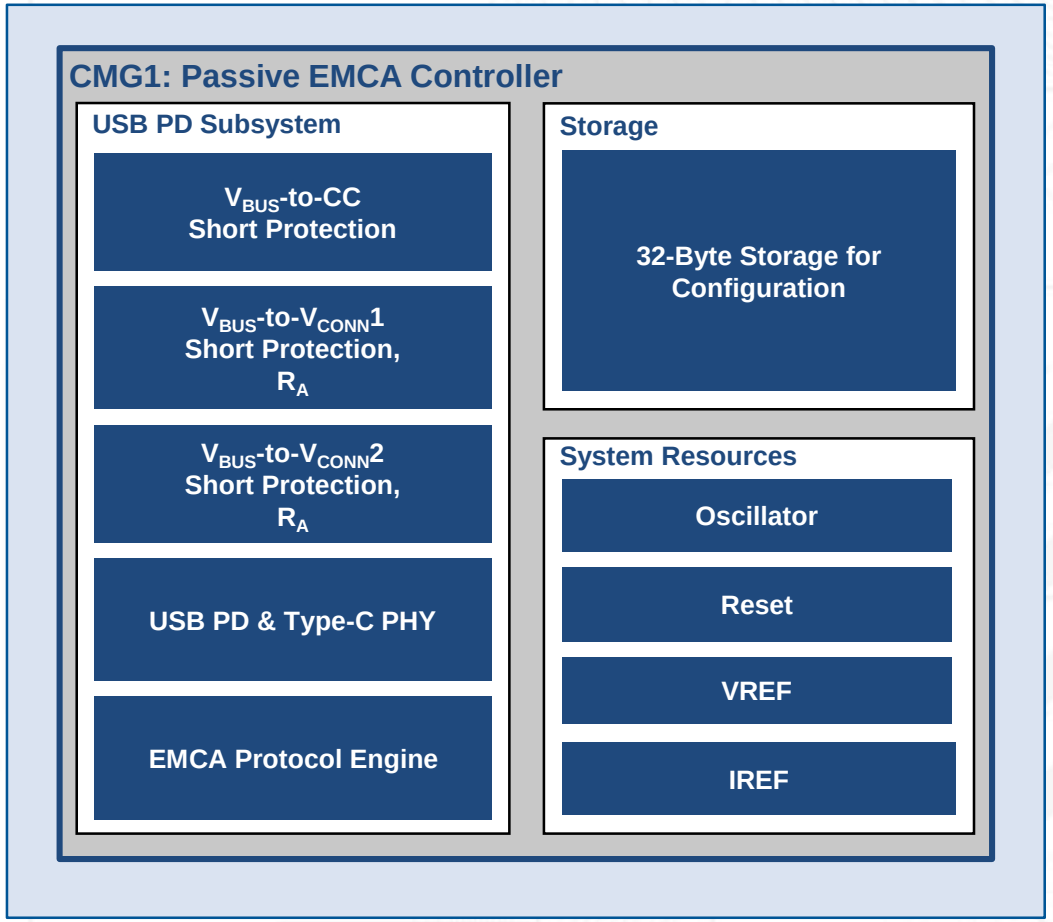
CMG1: USB-C Passive EMCA Controller

Applications

USB-C EMCA

Features

- **USB-C PD Controller, PD 3.0 Transceiver**
- **V_{BUS}-to-CC Short Protection**
- **V_{BUS}-to-V_{CONN} Short Protection**
- **Power from V_{CONN} Range 3.0–5.5-V**
- **Termination Resistor R_A**
- **Supports R_A Weakening to Reduce Power Consumption**
- **Configurable 32-byte Storage for Configuration Over Type-C Interface**
- **Integrated Oscillator Eliminating the Need for External Clock**
- **Power Operation**
  - 2.7–5.5-V operation (V_{CONN} pin)
  - Active: 7.5 mA
  - Sleep: 1 mA
- **System-Level ESD on CC, V_{CONN} Pins**
  - ±8-kV contact, ±15-kV Air Gap IEC61000-4-2 level 4C
- **Packages**
  - 9-ball WLCSP (1.95 mm^2)
  - Supports industrial temperature range (-40°C to +85°C)



Collateral

Preliminary Datasheet: CMG1 Datasheet

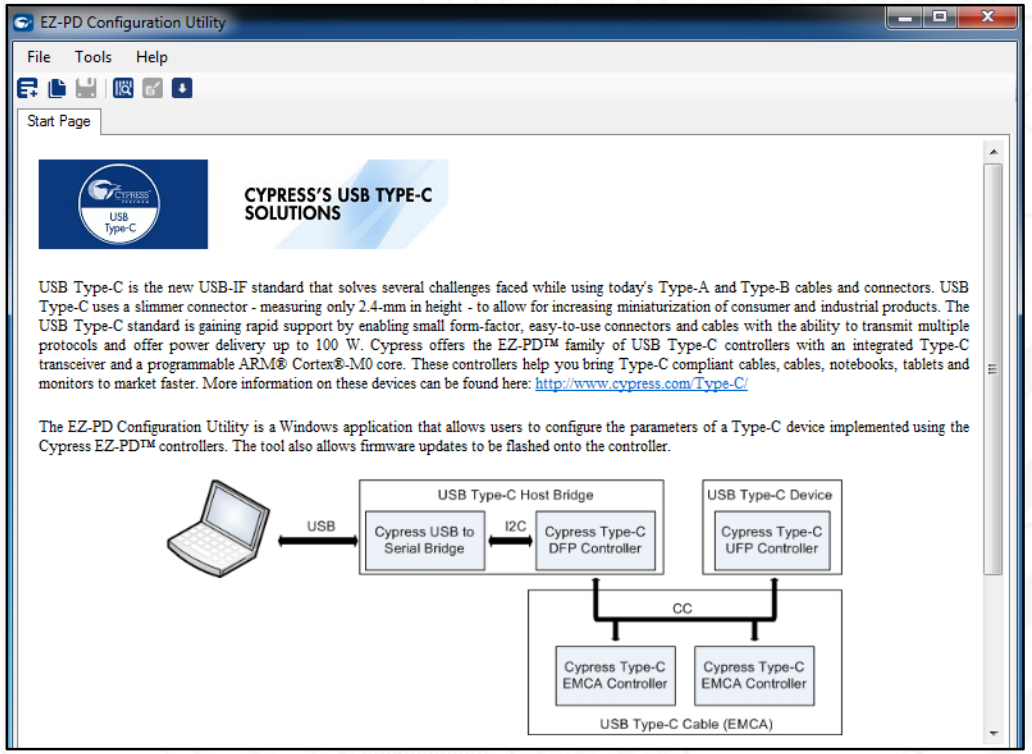
Availability

MP now

Getting Started

- **Go to the CMG1 product webpage and download the passive EMCA reference design**
  - Build the USB-C passive EMCA paddle card using the CMG1 reference design
- **Download the EZ-PD Configuration Utility to configure vendor- and cable-specific configuration data in the CMG1 of your USB-C cable**

Cypress' EZ-PD Configuration Utility



Getting Started

- Identify accounts that we can visit jointly
- Contact these customers with our scripted email
- Show them the CMG1 product webpage and datasheet
- Show them the USB-C passive EMCA paddle card reference design

References and Links

- **CMG1**
  - Web Page
    www.cypress.com/cmg1
  - Datasheet
    www.cypress.com/cmg1ds
  - Roadmap
    www.cypress.com/product-roadmaps/cypress-usb-controllers-roadmap
  - Overview
    www.cypress.com/documentation/product-overviews/ez-pd-cmg1-product-overview
  - Knowledge Base Article
    www.cypress.com/CCGx_KBAs
- **USB 3.1 Specification (including Type-C)**
  - www.usb.org/developers/docs
- **USB Power Delivery Specification**
  - www.usb.org/developers/powerdelivery

EZ-PD USB-C CCG3PA

CCG3PA = Type-C Controller Gen3 for Power Adapter

Add PD 3.0 and QC 4.0 to Your Charger Ports

CCG3PA: USB-C and Power Delivery Port Controller

Applications

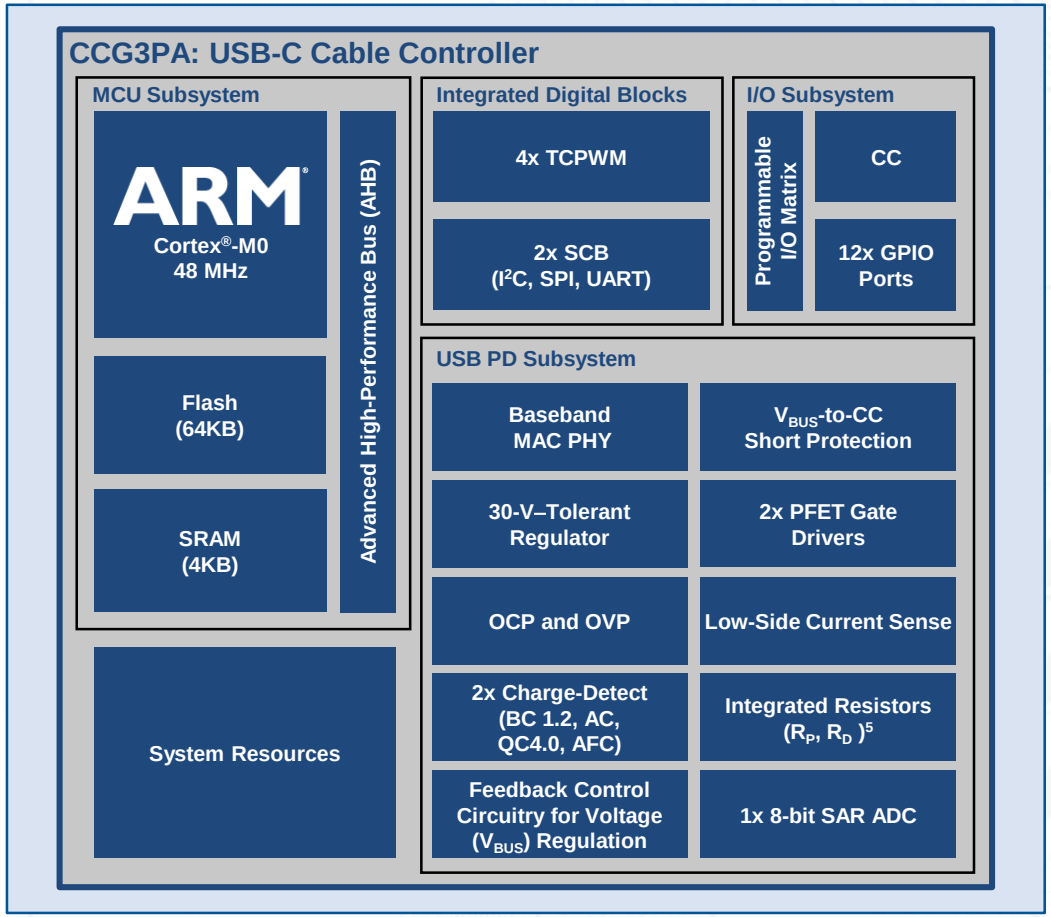
USB Type-C PD-based Automotive Chargers

Features

- **USB-C PD Controller, PD 3.0 Transceiver and Qualcomm QC 4.0**
- **V_{BUS}-to-CC Short Protection**
- **Integrated High-Voltage 30-V–Tolerant LDO to Power CCG3PA**
- **Integrated Digital Blocks**
  - Four timer/counter/pulse-width modulator (TCPWM) blocks, 12x GPIOs
  - Two serial communication blocks (SCBs) for configurable master/slave I^2C, SPI or UART
- **Integrated Analog Blocks**
  - Configurable V_{BUS} overvoltage protection (OVP) and overcurrent (OCP) protection
  - Integrated voltage regulation[1] with analog output and PFET gate drivers
  - Low-side current sense[2] capable of detecting 100mA change
  - Two legacy charge-detect block (BC 1.2, Apple Charging 2.4A, QC 4.0 and Samsung AFC[3])
- **ARM® Cortex®-M0 with MCU Subsystem and 64KB Flash**
- **Low-Power Operation**
  - High-voltage (3–30 V, 30 V maximum) V_{BUS} voltage inputs
  - Sleep: 3 mA; Deep Sleep: 30 µA with wake-on-CC
- **System-Level ESD on CC, Dp / Dn[4] and V_{BUS} Pins**
  - ±8-kV contact, ±15-kV Air Gap IEC61000-4-2 level 4C
- **Packages**
  - 24 QFN (Industrial), 24 QFN (Automotive) AEC-Q100 Grade-S

Collateral

Preliminary Datasheet: CCG3PA Datasheet



Availability

Production: Now

Samples: Q4 2018 (Auto) **Production:** Q1 2019 (Auto)

[1] Analog feedback control circuit to regulate V_{BUS}
[2] Circuit to measure the current flowing on the V_{BUS}
[3] Adaptive Fast Charging
[4] USB-C bus wires used to transmit and receive USB 2.0 data
[5] Termination resistors: R_P read as a DFP, R_D as a UFP

CYPRESS EMBEDDED IN TOMORROW™

CCG3PA Reference Design Partners

	DIODES INCORPORATED	power integrations	MPS Monolithic Power Systems	SOUTHCHIP	active-semi Solutions for Sustainability	Navitas
Mobile Charger 33-W PD 3.0 + QC 4.0	✓	✓	✓			✓
Notebook Power Adapter 45-W/60-W PD 3.0			✓			
Power Bank			✓	✓		
60-W Car Charger			✓	✓	✓	

Getting Started

- **CCG3PA Evaluation Kit provides:**
  - Support for power adapters/chargers and power banks
  - One Type-C source or sink port and Type-A source port
  - Support for USB PD 3.0 with PPS support
  - Support for QC 4.0, BC 1.2, Apple Charging 2.4A and Samsung AFC[1] charging protocols on Type-A port
  - Support for 1-cell and 2-cell battery (power bank application)
  - Charging for notebooks, mobile phones and USB-powered devices
  - Firmware upgradeability

$149 CCG3PA Evaluation Kit (CY4532)

[1] Adaptive Fast Charging

EZ-PD™ CCG3PA 1C&1A Power Adapter Design Overview

Daniel Shen (sxfs@cypress.com)

Training Agenda

CCG3PA Power Adapter/Charger Design Overview
1*Type-C and 1*Type-A Power Adapter Design with CCG3PA
Different Type of 1C/1A Power Adapter Design – Ⅰ
Different Type of 1C/1A Power Adapter Design –Ⅱ
Different Type of 1C/1A Power Adapter Design –Ⅲ
Temperature Based Power Throttling & Thermal Shutdown
Demo: Modifying CCG3PA Firmware Using the EZ-PD CCG3PA SDK
Debug Skills in CCG3PA Design
Q & A
End of Training

CCG3PA Power Adapter/Charger Design Overview

CCG3PA: USB-C and Power Delivery Port Controller

Applications

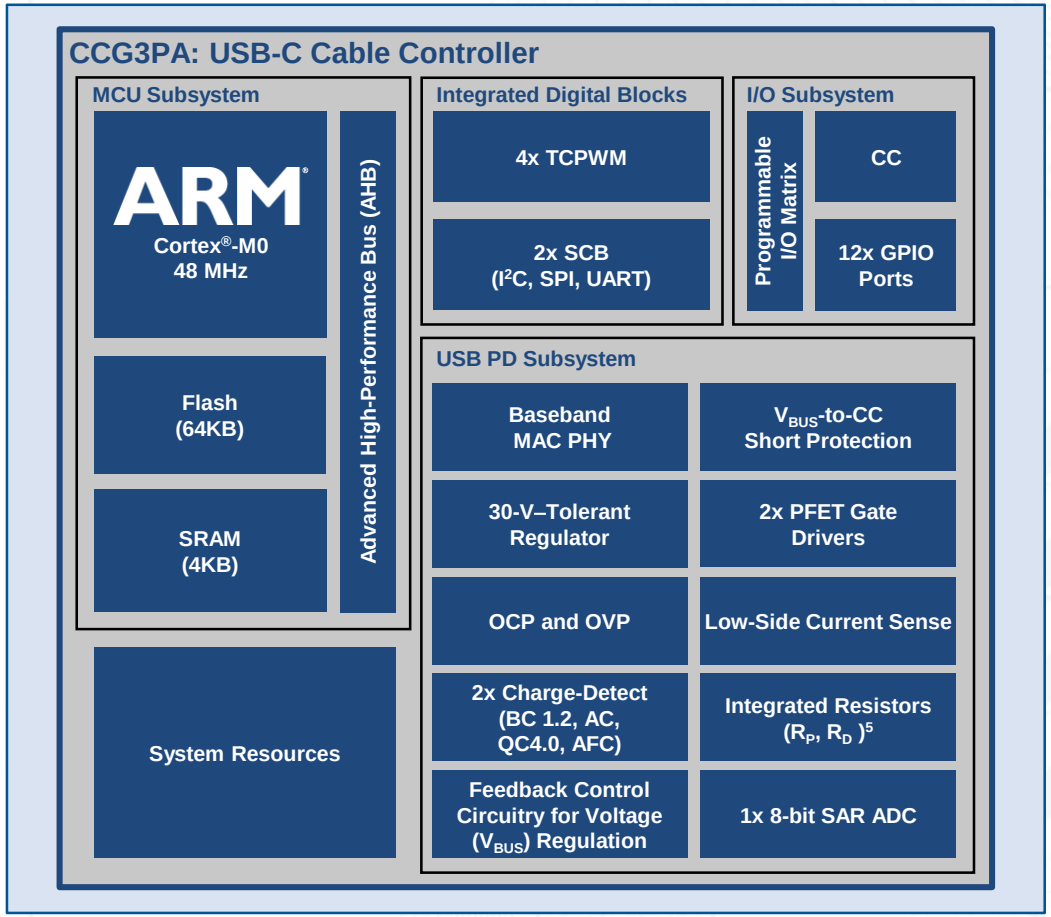
USB Type-C PD-based Automotive Chargers

Features

- **USB-C PD Controller, PD 3.0 Transceiver and Qualcomm QC 4.0**
- **V_{BUS}-to-CC Short Protection**
- **Integrated High-Voltage 30-V–Tolerant LDO to Power CCG3PA**
- **Integrated Digital Blocks**
  - Four timer/counter/pulse-width modulator (TCPWM) blocks, 12x GPIOs
  - Two serial communication blocks (SCBs) for configurable master/slave I^2C, SPI or UART
- **Integrated Analog Blocks**
  - Configurable V_{BUS} overvoltage protection (OVP) and overcurrent (OCP) protection
  - Integrated voltage regulation[1] with analog output and PFET gate drivers
  - Low-side current sense[2] capable of detecting 100mA change
  - Two legacy charge-detect block (BC 1.2, Apple Charging 2.4A, QC 4.0 and Samsung AFC[3])
- **ARM® Cortex®-M0 with MCU Subsystem and 64KB Flash**
- **Low-Power Operation**
  - High-voltage (3–30 V, 30 V maximum) V_{BUS} voltage inputs
  - Sleep: 3 mA; Deep Sleep: 30 µA with wake-on-CC
- **System-Level ESD on CC, Dp / Dn[4] and V_{BUS} Pins**
  - ±8-kV contact, ±15-kV Air Gap IEC61000-4-2 level 4C
- **Packages**
  - 24 QFN (Industrial), 24 QFN (Automotive) AEC-Q100 Grade-S

Collateral

Preliminary Datasheet: CCG3PA Datasheet



Availability

Production: Now

Samples: Q4 2018 (Auto) **Production:** Q1 2019 (Auto)

[1] Analog feedback control circuit to regulate V_{BUS}
[2] Circuit to measure the current flowing on the V_{BUS}
[3] Adaptive Fast Charging
[4] USB-C bus wires used to transmit and receive USB 2.0 data
[5] Termination resistors: R_P read as a DFP, R_D as a UFP

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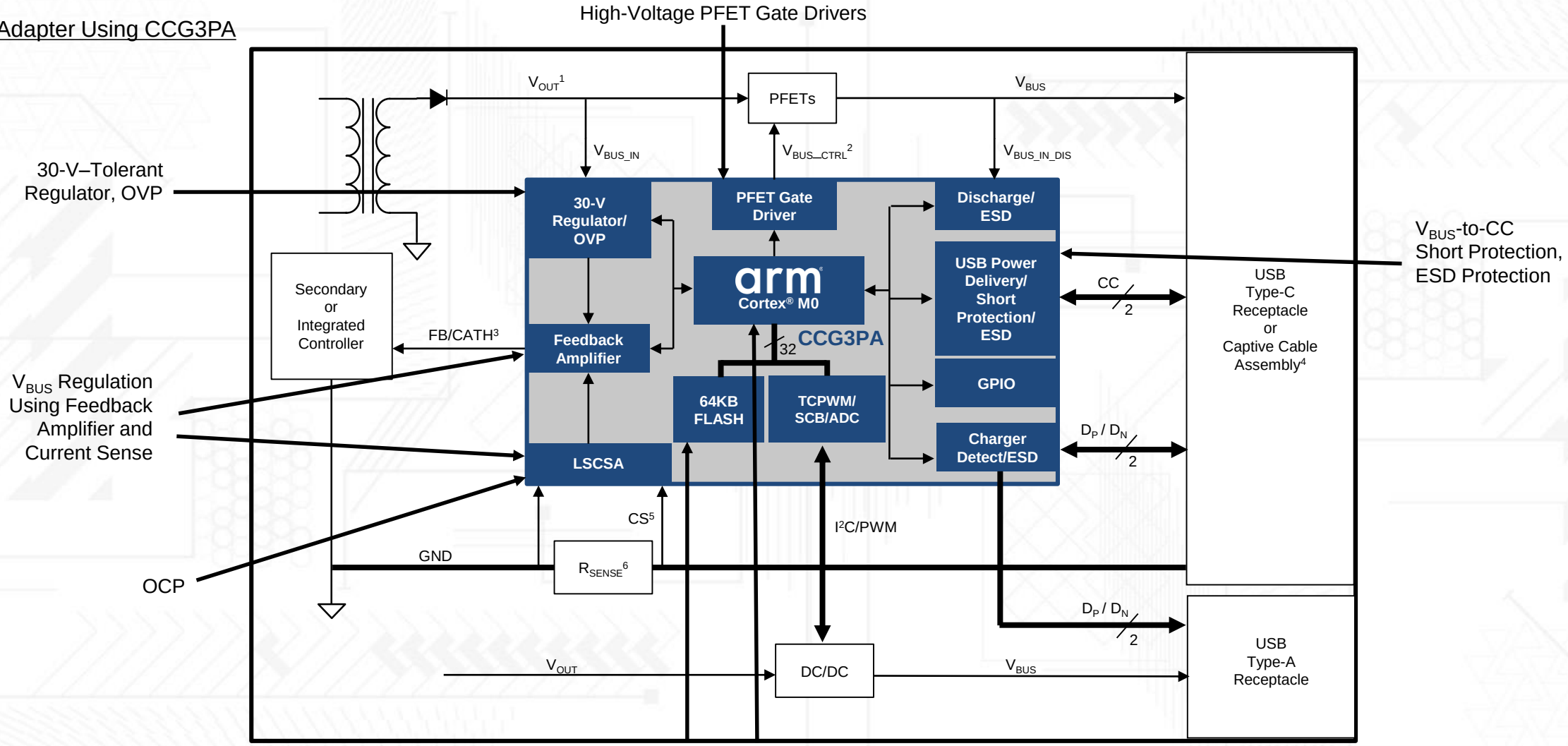
CCG3PA Simplifies System Design with BOM Integration

Power Adapter Using CCG3PA



Arm® Cortex®-M0 and 64KB Flash Supports Firmware Update

[1] Output voltage of the AC-to-DC adapter
[2] Signal to control V_{BUS} load switch
[3] Output voltage selection using feedback control
[4] A cable permanently attached to the AC adapter
[5] Current-sensing input
[6] Resistor used to sense overcurrent

CCG3PA Solution Example:

Type-C Power Adapter/Mobile Charger

CCG3PA Value

- **Design Problems**
  - Power adapter/mobile charger must support latest standards
  - Must be turnkey for ease-of-design
  - Must be highly integrated to lower BOM cost
  - Must be reprogrammable to keep up with USB-IF standards
  - Industry standards demand low power for no-load conditions
- **CCG3PA Solution**
  - Provides Type-C solution with Power Delivery 3.0 (PD 3.0) with programmable power supply support and Quick Charge 4.0 (QC 4.0)
  - Includes an Arm® Cortex®-M0 and certified USB-PD stack
  - Integrates voltage regulation, 30-V–tolerant regulator, V_{BUS}-to-CC short protection, high-voltage PFET gate driver, and ESD protection
  - Supports field upgrades with free, fully compliant firmware
  - Delivers low power: 30 µA (Deep Sleep mode)

Suggested Collateral

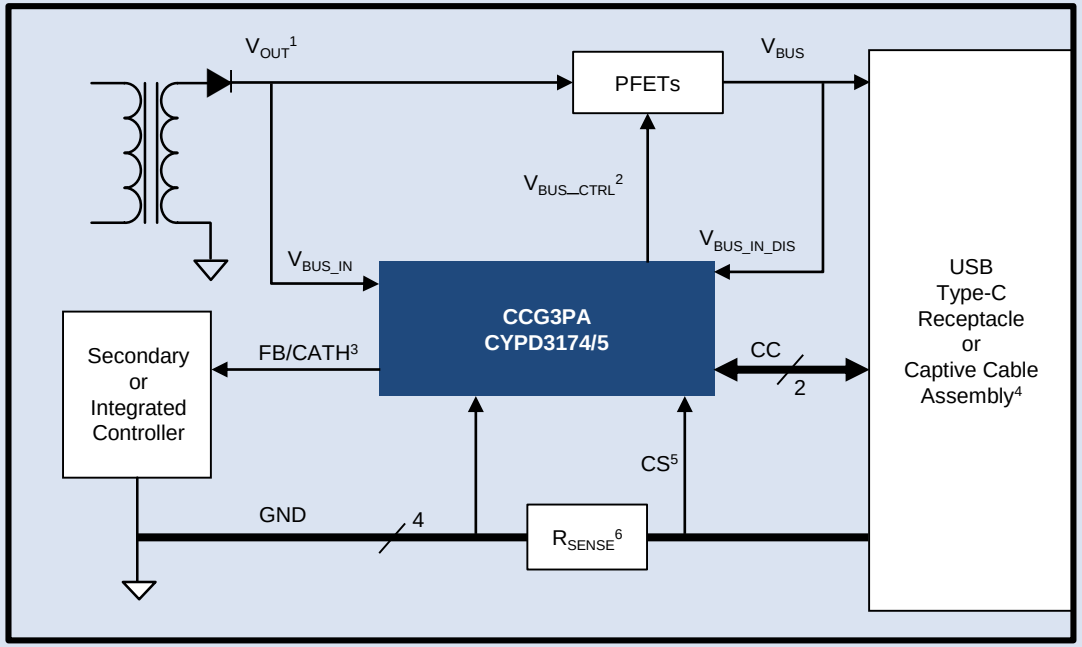
Webpages: Type-C, CCG3PA, and Reference Design

Datasheet: CCG3PA Datasheet

How to Get Started

Contact Sales for CCG3PA Evaluation Board

Type-C Power Adapter/Mobile Charger with CCG3PA



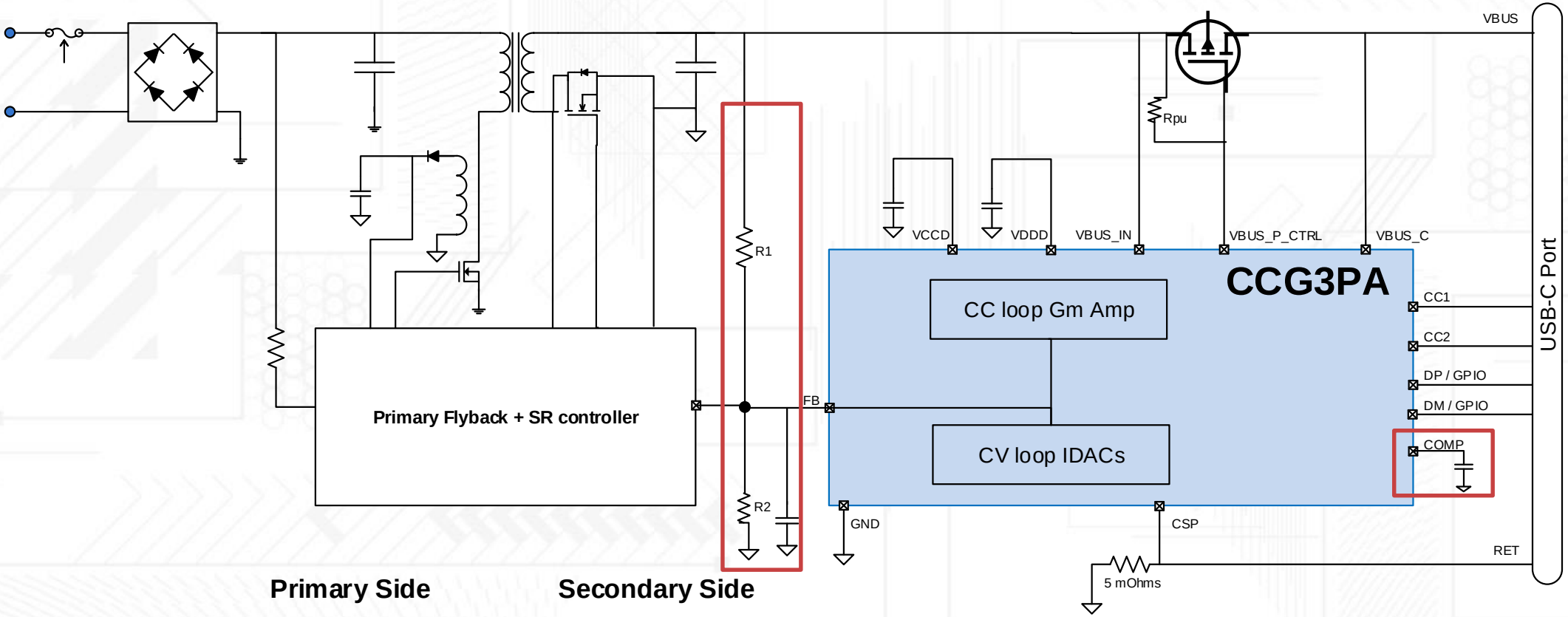
New Smartphone Charger With USB-C Receptacle

CCG3PA supports QC 4.0 and PD 3.0 PPS, which are required for cellphone chargers

[1] Output voltage of the AC-to-DC adapter
[2] Signal to control V_{BUS} load switch
[3] Output voltage selection using feedback control
[4] A cable permanently attached to the AC adapter
[5] Current-sensing input
[6] Resistor used to sense overcurrent

Direct Feedback System

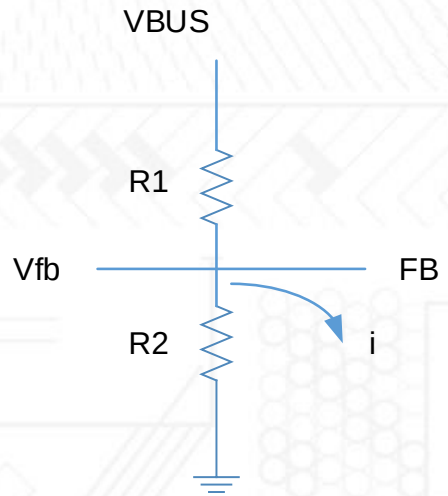
- In direct feedback system, CCG3PA provides feedback to the upstream power converter by modulating the current drawn on the Feedback (FB) pin.



Direct Feedback System

- **The relationship between VBUS, feedback voltage and resistor dividers:**

$$V_{fb} = \frac{VBUS - i * R_1}{R_1 + R_2} * R_2 \qquad \Delta VBUS = i * R_1$$

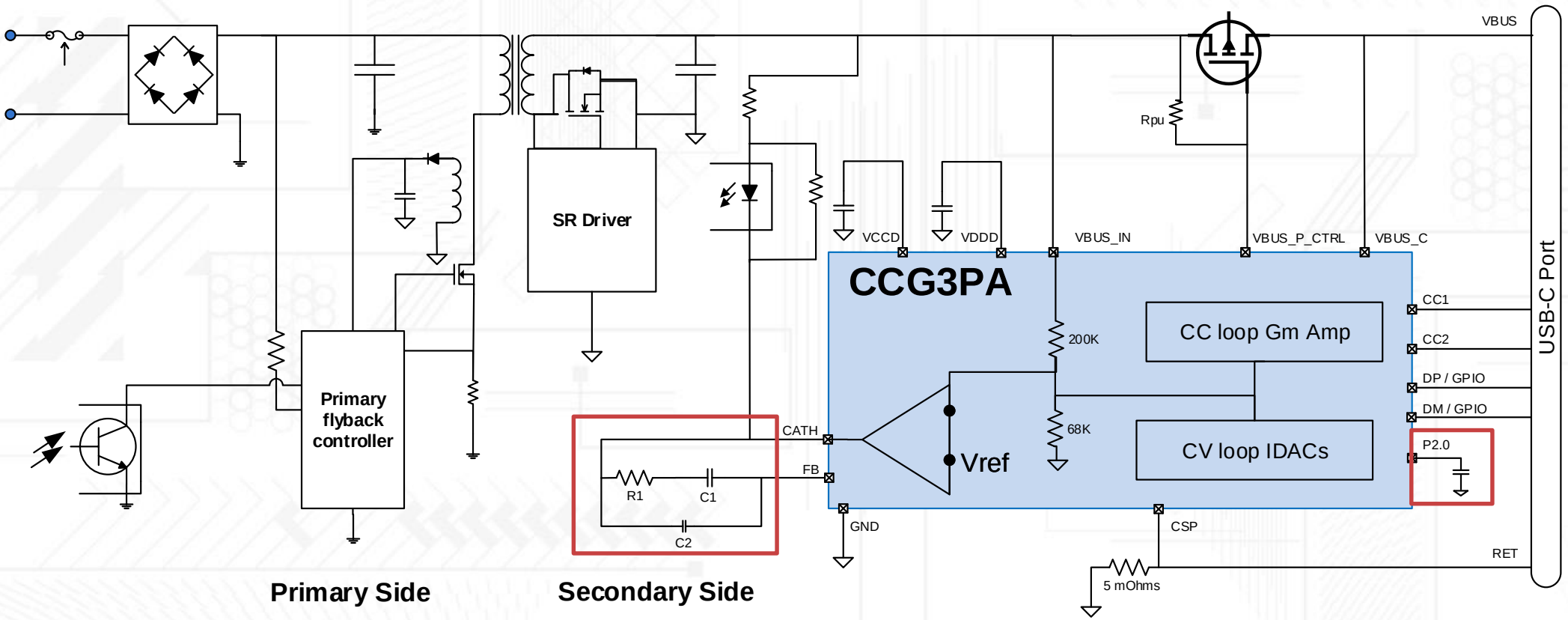


- **Key points to calculate feedback resistors R1 and R2**
  - The default VBUS voltage is dictated by external resistor dividers. External resistors R1 and R2 must be chosen such that at 5V VBUS, without CCG3PA sourcing or sinking any current on the FB pin, the voltage at the feedback node shall be the default feedback voltage expected by the power converter.
  - The CV loop IDACs can sink up to 102.3 µA of current and can source up to 12.7 µA of current.
  - Both the IDAC source and sink have a step size of 100 nA.
  - VBUS output range (3.3V ~ 21V)
  - Support Programmable Power Supply mode (20mV Step)

$$R_1 = 200k$$

Opto Feedback System

- In opto feedback system, CCG3PA regulates VBUS by controlling the current drawn through the cathode (CATH) node.



Type-C Reference Designs

- **Click Here for all Type-C Reference Designs**

Overview | USB PD 3.0 | Features | Products | Kits | **Reference Designs** | Design Support | Videos | Presentations

Cypress has developed numerous Type-C reference designs using CCGx to help reduce your design cycle time, effort and risk. Each reference design has been built and tested.

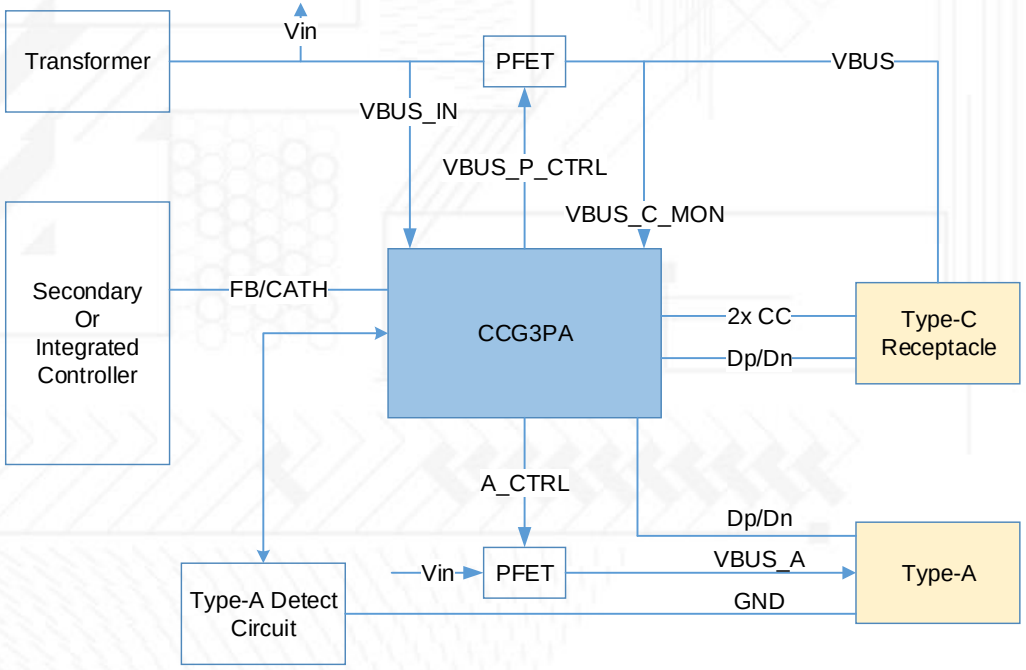
Applications	CCG1	CCG2	CCG3	CCG4	HX3C	CCG3PA	CMG1
Electronically Marked Cable Assembly (EMCA)	Available	Available	-	-	-	-	Available
Type-C to Legacy USB	Available	-	-	-	-	-	-
Type-C to DisplayPort	Available	Available	Available	-	-	-	-
Type-C to HDMI/VGA/DVI	Available	Available	Available	-	-	-	-
Monitor/Dock	-	Available	-	Available	Available	-	-
Charge-Through Dongle	-	-	Available	-	-	-	-
18W Power Adapter	-	Available	-	-	-	-	-
20W Power Adapter	-	Available	-	-	-	-	-
24W Power Adapter	-	Available	-	-	-	-	-
Car Charger	-	Available Available	-	-	-	Available (Southchip) Available (Active-Semi)	-
Power Bank	-	Available	Available	-	-	Available (Southchip 18W) Available (Southchip 45W)	-
QC4.0 Cell Phone chargers 27W	-	-	-	-	-	Available (Power Integration) Available (Diodes)	-
Notebook Adapter 45W	-	-	-	-	-	Available (MPS)	-
HDMI over USB-C Alternate Mode	-	-	Available	-	-	-	-

Please submit a case in the Online Tech Support Case System for any further information.

1*Type-C and 1*Type-A Power Adapter Design with CCG3PA

Different Type of 1C/1A Power Adapter Design – I

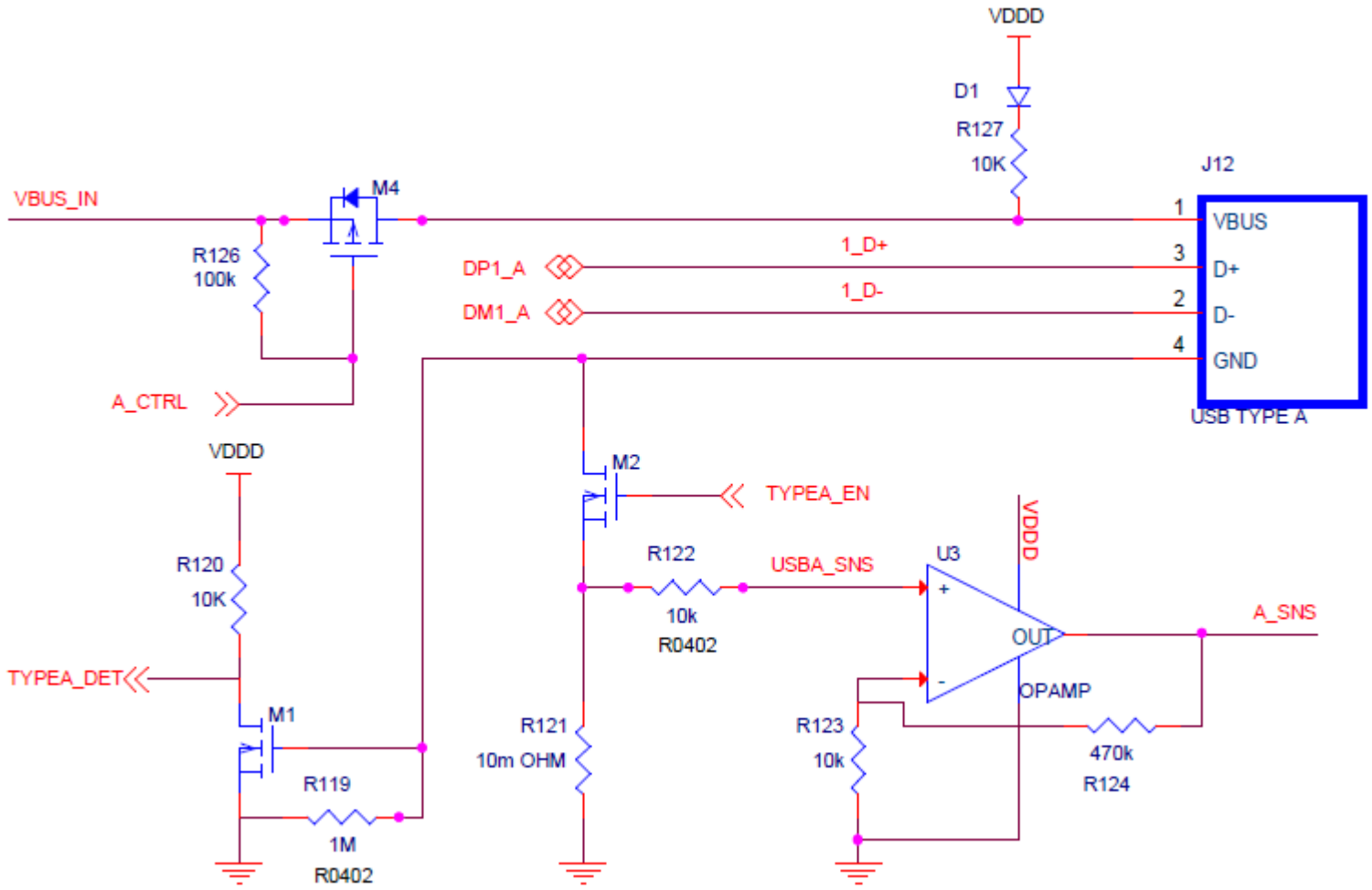
- **Requirement**
  - Type-C port support PD 27W and legacy charging
  - Type-A port support legacy charging 18W (Apple Charging, BC1.2, QC2.0, QC3.0, AFC etc.)
  - If both Type-C and Type-A port are plugged in, only 5V could provide to two ports.
- **Block Diagram**



- Why need a PFET in VBUS_A path?
- What's the function of Type-A detect circuit?
- How to design a Type-A detect circuit?

Different Type of 1C/1A Power Adapter Design – I

- Type-A Detect Circuit



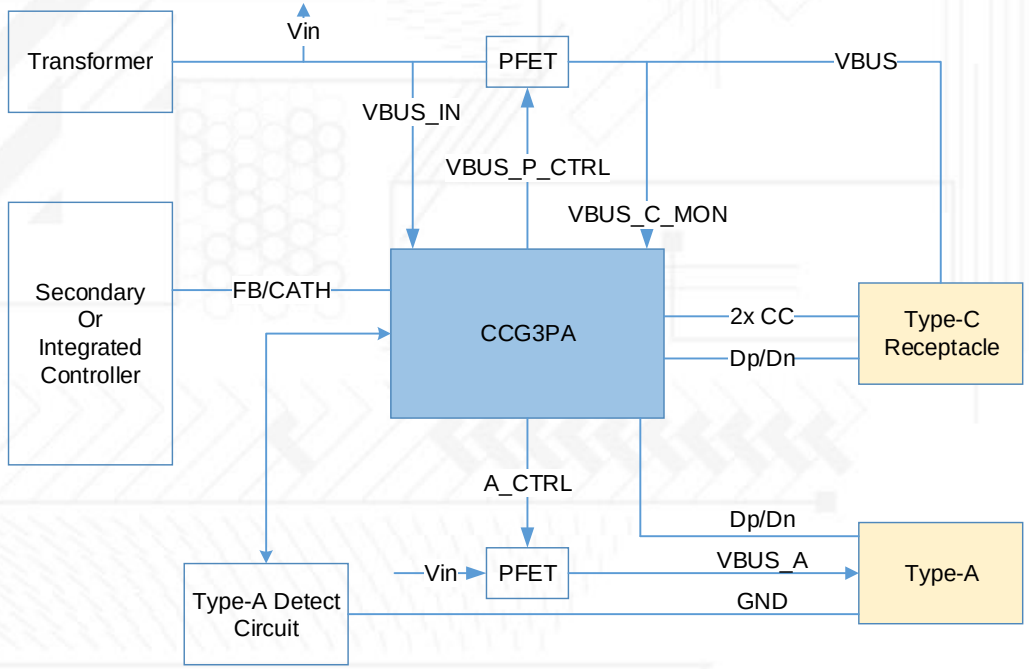
- Device plug in detect
- Device plug out detect

Different Type of 1C/1A Power Adapter Design – I

- **Control Logic for Type-C and Type-A Port**
  - If there is no device on Type-C port, enable Type-A output that A_CTRL is low and TYPEA_EN is high. A_SNS is measured to get Type-A charging current value(cur_a)
  - If a device is plugged in on Type-C port
    - If cur_a > cur_a_threshold, change Type-C source PDO is 5V@3A and change Type-A legacy charging is only BC1.2 and Apple Charging.
    - If cur_a < cur_a_threshold, disable Type-A output that A_CTRL is high and TYPEA_EN is low. And change Type-C source PDO is 5V@3A and 9V@3A etc. Start to check TYPEA_DET status to detect that device is plugged to Type-A port.
  - If a device is plugged in on Type-A port
    - If Type-A output is already disabled and TYPEA_DET is low, change Type-C source PDO is 5V@3A and change Type-A legacy charging is only BC1.2 and Apple Charging. Then enable Type-A output.
- **Limitation**
  - If cur_a < cur_a_threshold, Type-A port device is identified as detached. For some devices, it can't be fully charged.

Different Type of 1C/1A Power Adapter Design –Ⅱ

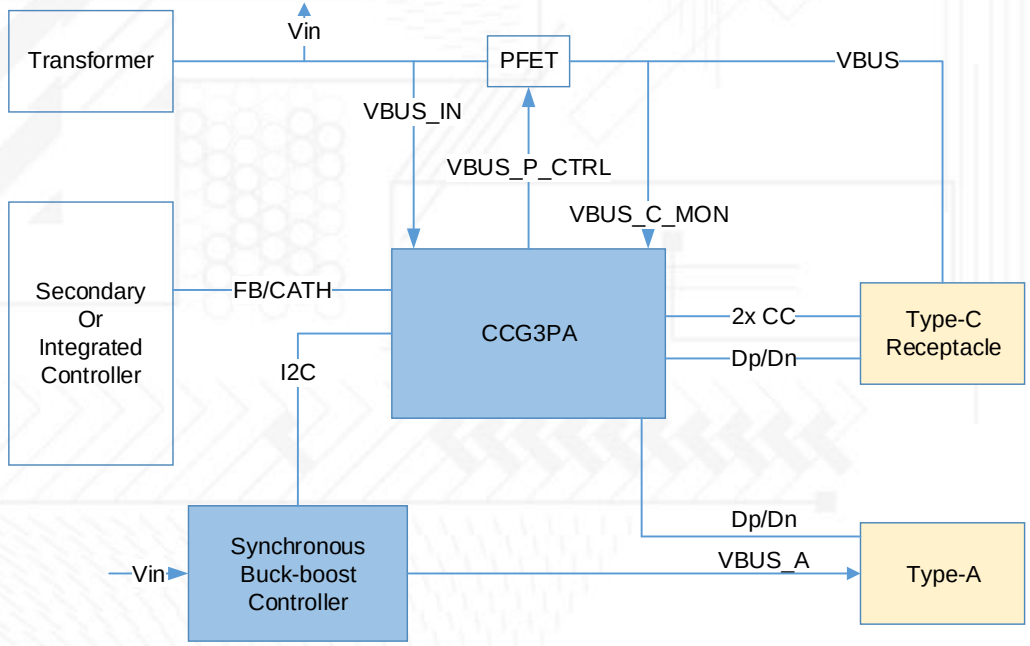
- **Requirement**
  - Type-C port support PD 45W and legacy charging
  - Type-A port support legacy charging 18W (Apple Charging, BC1.2, QC2.0, QC3.0, AFC etc.)
  - If both Type-C and Type-A port are plugged in, Type-C port support PD 27W and legacy charging and Type-A port still support legacy charging 18W
- **Block Diagram**



- Does it need a PFET in VBUS_A path?
- What should be changed in the last design?
  （The block diagram is still Type Ⅰ）

Different Type of 1C/1A Power Adapter Design –Ⅱ

- **Requirement**
  - Type-C port support PD 45W and legacy charging
  - Type-A port support legacy charging 18W (Apple Charging, BC1.2, QC2.0, QC3.0, AFC etc.)
  - If both Type-C and Type-A port are plugged in, Type-C port support PD 27W and legacy charging and Type-A port still support legacy charging 18W
- **Block Diagram**



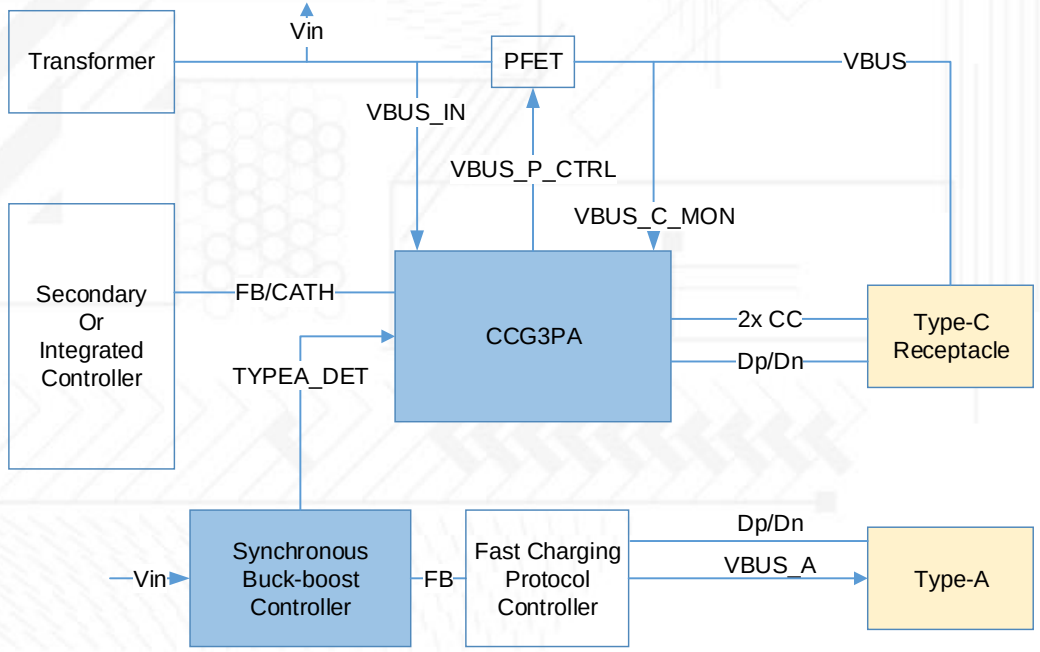
- How to detect that a device is plugged in?

Different Type of 1C/1A Power Adapter Design –Ⅱ

- **Control Logic for Type-C and Type-A Port**
  - If there is no device on Type-C port, enable Type-A output and keep reading Type-A charging current value(cur_a) by I2C.
  - If a device is plugged in on Type-C port
    - If cur_a > cur_a_threshold, change Type-C output power to be 27W. And limit input current of DC-DC based on Type-C output voltage.
    - If cur_a < cur_a_threshold, change Type-C output power to be 45W. And keep reading Type-A charging current value(cur_a) by I2C.
  - If a device is plugged in on Type-A port
    - If a device is already plugged to Type-C port and cur_a > cur_a_threshold, change Type-C output power to be 27W.
- **Limitation**
  - If cur_a < cur_a_threshold, Type-A port device is identified as detached. For some devices, it can't be fully charged.

Different Type of 1C/1A Power Adapter Design –Ⅱ

- **Requirement**
  - Type-C port support PD 45W and legacy charging
  - Type-A port support legacy charging 18W (Apple Charging, BC1.2, QC2.0, QC3.0, AFC etc.)
  - If both Type-C and Type-A port are plugged in, Type-C port support PD 27W and legacy charging and Type-A port still support legacy charging 18W
- **Block Diagram**



Different Type of 1C/1A Power Adapter Design –Ⅲ

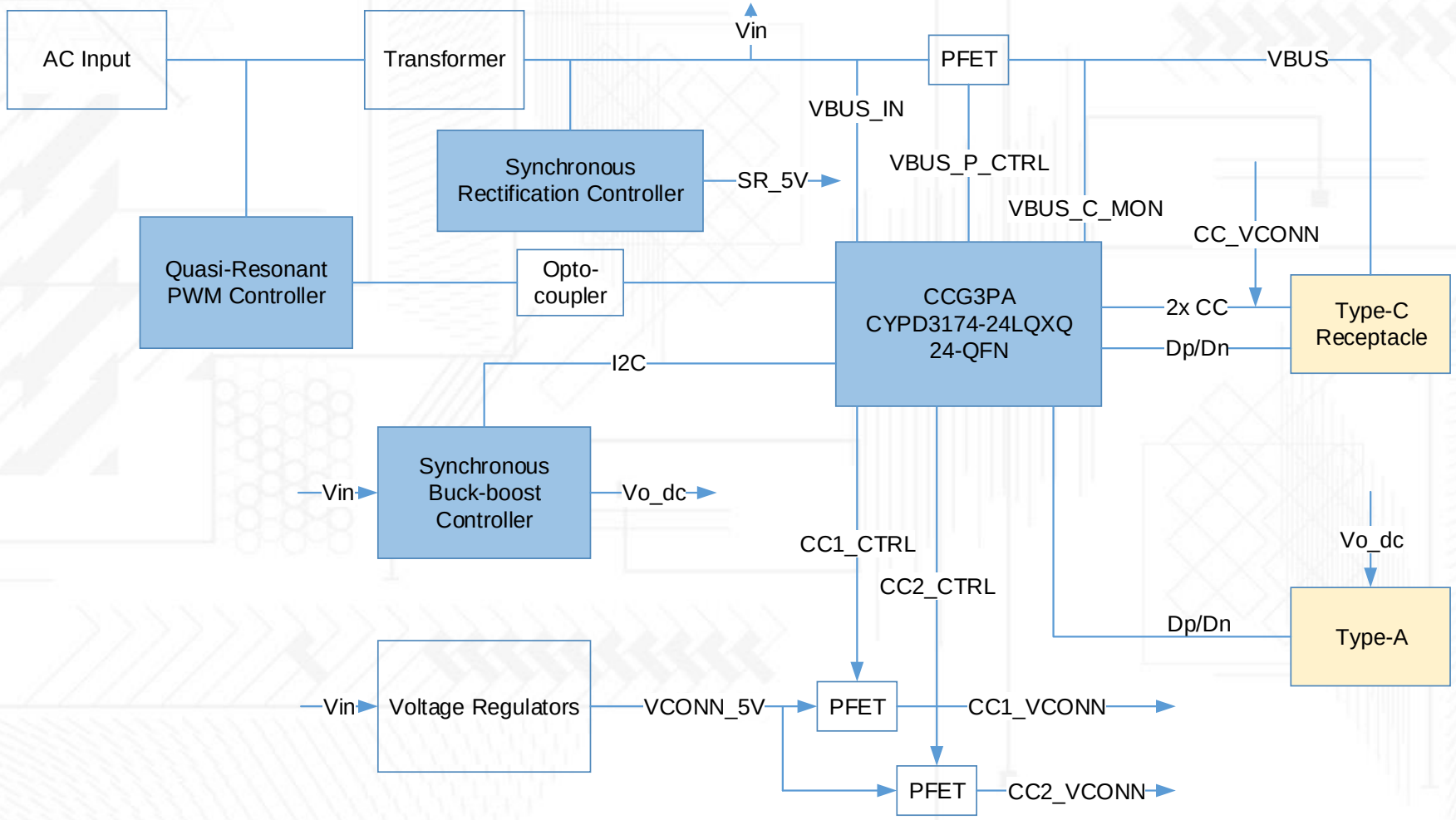
- **Requirement**
  - Type-C port support PD 65W and legacy charging
  - Type-A port support legacy charging 18W (Apple Charging, BC1.2, QC2.0, QC3.0, AFC etc.)
  - If both Type-C and Type-A port are plugged in, Type-A port output power is limited by Type-C port output power.

Type-C Output	Type-A Output and Legacy Charging Supported
0 ~ 45W	18W (Apple Charging, BC1.2, QC2.0, QC3.0, AFC)
45 ~ 60W	10W (Apple Charging, BC1.2)
60 ~ 65W	5W (BC1.2)

- Does it need to detect that a Type-A device is plugged in?

Different Type of 1C/1A Power Adapter Design –Ⅲ

- **Block Diagram**



Different Type of 1C/1A Power Adapter Design –Ⅲ

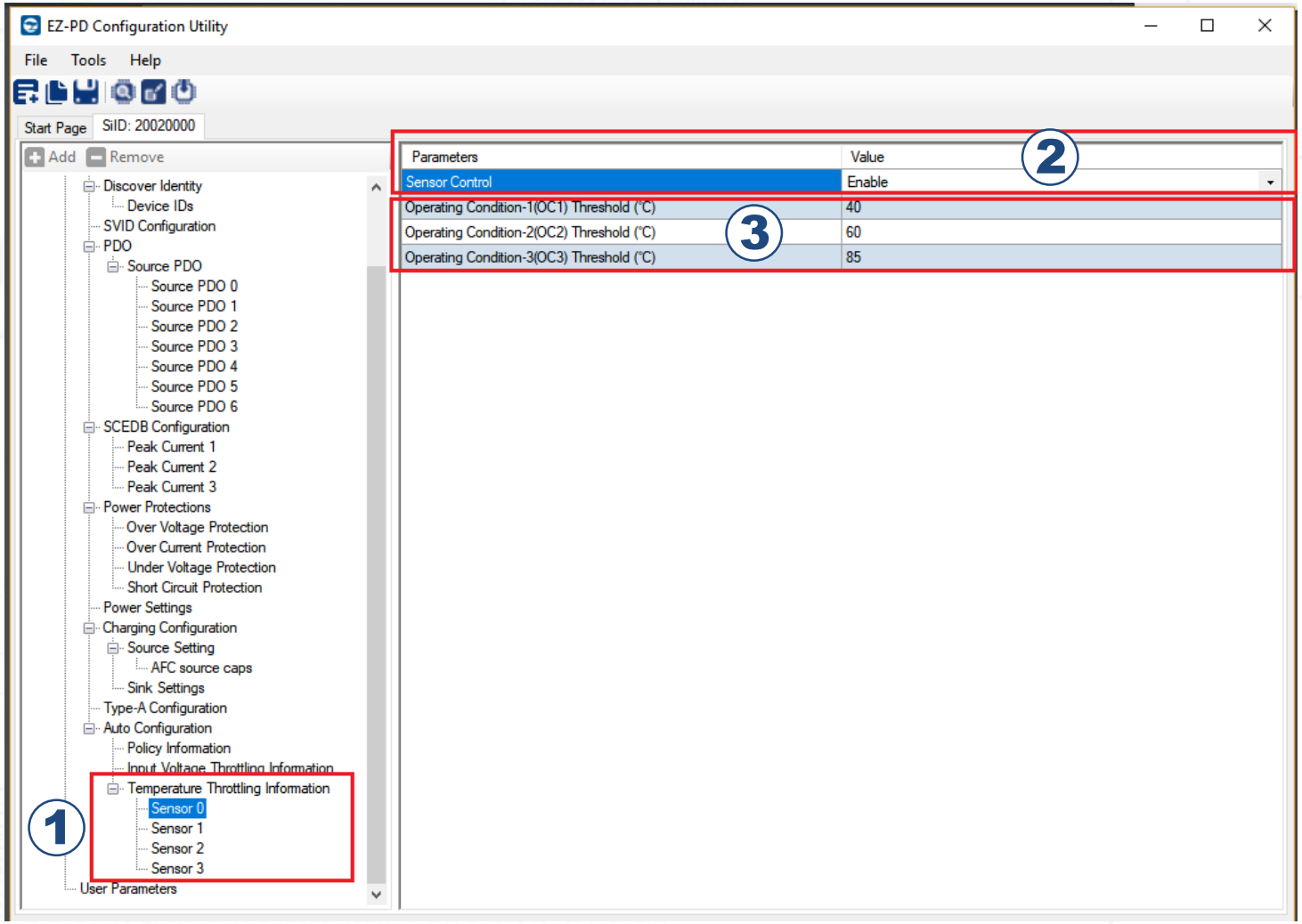
- **Control Logic for Type-C and Type-A Port**
  - If there is device on Type-C port and the device request power is lower than or equal with 45W, all legacy charging are supported on Type-A port. And limit input current of DC-DC based on Type-C output voltage and output current of DC-DC based on voltage value device request.
  - If the device request power is more than 45W and lower than or equal with 60W, disable Type-A port output for a while and change legacy charging to be Apple Charging and BC1.2. Then enable Type-A port output.
  - If the device request power is more than 60W and lower than or equal with 65W, disable Type-A port output for a while and change legacy charging to be BC1.2. Then enable Type-A port output.

- **Key Point in This Design**
  - How to disable Type-A port output and enable it again?
  - How to limit Type-A port output power?

Temperature Based Power Throttling & Thermal Shutdown

Auto Configuration in EZ-PD Configuration Utility

EZ-PD Configuration Utility GUI



1. The parameter to handle Temperature Throttling is located under **Auto Configuration → Temperature Throttling Information**

   - Allows 4 sensor configuration.

2. **Sensor Control** option allows you enable/ disable the temperature monitoring.

3. **Operating Condition thresholds:**

   OC1 – Temperature below which the CCG3PAs provide 100% power budget.

   OC2 – If temperature is between OC1 and OC2 then the CCG3PAs will operate at 50% power budget.

   OC3 – If temperature is between OC2 and OC3 then the CCG3PAs will operate at 5V@3A. For Temperature > OC3, CCG3PA will shut down.

View EZ-PD Analyzer Utility Data for Temperature Throttling

SL#	Status	SOP	Message	Msg Id	Data Role	Power Role	Obj Count	Data	Start Time (us)	Duration (us)	Delta (us)	VBUS Voltage(V)	VBUS Current(A)
1	OK	SOP_PRIME	VDM	0	Reserved	DFP/UFP	1	0x108F 0xFF00A001	7,476,594	631			
2	OK	SOP_PRIME	GoodCRC	0	Reserved	Cable	0	0x141	7,477,401	496			
3	OK	SOP_PRIME	VDM	0	Reserved	Cable	5	0x514F 0xFF008041 0x1C002B1D 0x0 0x12010...	7,479,637	1,155			
4	OK	SOP_PRIME	GoodCRC	0	Reserved	DFP/UFP	0	0x41	7,480,938				
5	OK	SOP	Source_Cap	0	DFP	Source	7	0x71A1 0xB01912C 0x2D12C 0x4B12C 0x641F...	7,482,470				
6	OK	SOP	GoodCRC	0	UFP	Sink	0	0x41	7,484,046	504			
7	OK	SOP	Request	0	UFP	Sink	1	0x1082 0x4287D1F4	7,485,621	637			
8	OK	SOP	GoodCRC	0	DFP	Source	0	0x161	7,486,404	498			
9	OK	SOP	Accept	1	DFP	Source	0	0x3A3	7,488,039	498			
10	OK	SOP	GoodCRC	1	UFP	Sink	0	0x241	7,488,686	504			
11	OK	SOP	PS_RDY	2	DFP	Source	0	0x5A6	7,619,328	499			
32	OK	SOP	VDM	4	DFP	Sink	1	0x18AF 0xFF00A001	7,670,072	638	1,650	19,992	N/A
33	OK	SOP	GoodCRC	4	UFP	Source	0	0x941	7,670,855	499			
34	OK	SOP	VDM	5	UFP	Source	4	0x4B8F 0xFF00A041 0x18004B4 0x0 0xF66400...	7,672,212	1,029			
35	OK	SOP	GoodCRC	5	DFP	Sink	0	0xA61	7,673,390	502			
36	OK	SOP	Source_Cap	6	UFP	Source	7	0x7D81 0xB01912C 0x2D12C 0x4B12C 0x640F...	31,295,619				
37	OK	SOP	GoodCRC	6	DFP	Sink	0	0xC61	31,297,196				
38	OK	SOP	Request	5	DFP	Sink	1	0x1AA2 0x1684B12C	31,299,080	637			
39	OK	SOP	GoodCRC	5	UFP	Source	0	0xB41	31,299,863	498			
40	OK	SOP	Accept	7	UFP	Source	0	0xF83	31,301,689	499			
41	OK	SOP	GoodCRC	7	DFP	Sink	0	0xE61	31,302,335	503			
42	OK	SOP	PS_RDY	0	UFP	Source	0	0x186	31,441,747	499			
43	OK	SOP	GoodCRC	0	DFP	Sink	0	0x61	31,442,395	504			
36	OK	SOP_PRIME	VDM	0	Reserved	DFP/UFP	1	0x108F 0xFF00A001	60,386,136	631			
37	OK	SOP_PRIME	GoodCRC	0	Reserved	Cable	0	0x141	60,386,942	496			
38	OK	SOP_PRIME	VDM	0	Reserved	Cable	5	0x514F 0xFF008041 0x1C002B1D 0x0 0x12010...	60,388,996	1,155			
39	OK	SOP_PRIME	GoodCRC	0	Reserved	DFP/UFP	0	0x41	60,390,288	499			
40	OK	SOP	Source_Cap	0	DFP	Source	2	0x21A1 0xB01912C 0xC876213C	60,391,784				
41	OK	SOP	GoodCRC	0	UFP	Sink	0	0x41	60,392,696				
42	OK	SOP	Request	0	UFP	Sink	1	0x1082 0x1684B12C	60,394,195	638			
43	OK	SOP	GoodCRC	0	DFP	Source	0	0x161	60,394,978	499			
44	OK	SOP	Accept	1	DFP	Source	0	0x3A3	60,396,832	499			
45	OK	SOP	GoodCRC	1	UFP	Sink	0	0x241	60,397,480	503			
46	OK	SOP	PS_RDY	2	DFP	Source	0	0x5A6	60,433,569	498			

Power Data Obj-Source 4	0x641F4
Type (31..30)	Fixed
Dual-Role Power (29)	No (0)
USB Suspend Supported (28)	No (0)
Externally Powered (27)	No (0)
USB Communications Capable (26)	No (0)
Data Role Swap (25)	No (0)
Reserved (24...22)	0
Peak Current (21...20)	IOC (default)
Volt in 50mV (19...10)	400(20V)
Max Current in 10mA (9...0)	500(5A)

Power Data Obj-Source 4	0x640FA
Type (31..30)	Fixed
Dual-Role Power (29)	No (0)
USB Suspend Supported (28)	No (0)
Externally Powered (27)	No (0)
USB Communications Capable (26)	No (0)
Data Role Swap (25)	No (0)
Reserved (24...22)	0
Peak Current (21...20)	IOC (default)
Volt in 50mV (19...10)	400(20V)
Max Current in 10mA (9...0)	250(2.50A)

Power Data Obj-Source 1	0xB01912C
Type (31..30)	Fixed
Dual-Role Power (29)	No (0)
USB Suspend Supported (28)	No (0)
Externally Powered (27)	Yes (1)
USB Communications Capable (26)	No (0)
Data Role Swap (25)	Yes (1)
Reserved (24...22)	0
Peak Current (21...20)	IOC (default)
Volt in 50mV (19...10)	100(5V)
Max Current in 10mA (9...0)	300(3A)

1. Sensor 1 Temperature < OC1 : (100W) PDOS: 5V@3A, 9V@ 3A, 15V@3A , 20V@ 5A & PPS APDO 3.3V- 21V@5A

2. Sensor 1 Temperature > OC1 && Sensor 1 Temperature < OC2 : (50W) PDOS: 5V@3A, 9V@ 3A, 15V@3A , 20V@ 2.5A & PPS APDO 3.3V- 21V@2.5A

3. Sensor 1 Temperature > OC2 && Sensor 1 Temperature < OC3 : (15W) PDOS: 5V@3A, PPS APDO 3.3V- 5V@3A

Demo: Modifying CCG3PA Firmware Using the EZ-PD CCG3PA SDK

Demo: Modifying CCG3PA Firmware Using the EZ-PD CCGx Power SDK

- **Objectives**
  - Learn to use the EZ-PD CCGx Power SDK
  - Modify the CCG3PA power adapter firmware application for a customer-specific design requirement using the EZ-PD CCGx Power SDK
  - Program the CCG3PA device on a CY4532 EZ-PD CCG3PA EVK with this modified firmware using the EZ-PD Configuration Utility and test it using the USBCEE Power Tester and CY4500 EZ-PD Protocol Analyzer
- **Hardware tools**
  - EZ-PD CCG3PA Evaluation Kit (CY4532)
  - EZ-PD Protocol Analyzer (CY4500)
  - USBCEE PAT Board
- **Software tools**
  - PSoC Creator 4.2
  - EZ-PD CCGx Power SDK
  - EZ-PD Configuration Utility
  - USBCEE Power Tester

Demo: Modifying CCG3PA Firmware Using the EZ-PD CCGx Power SDK

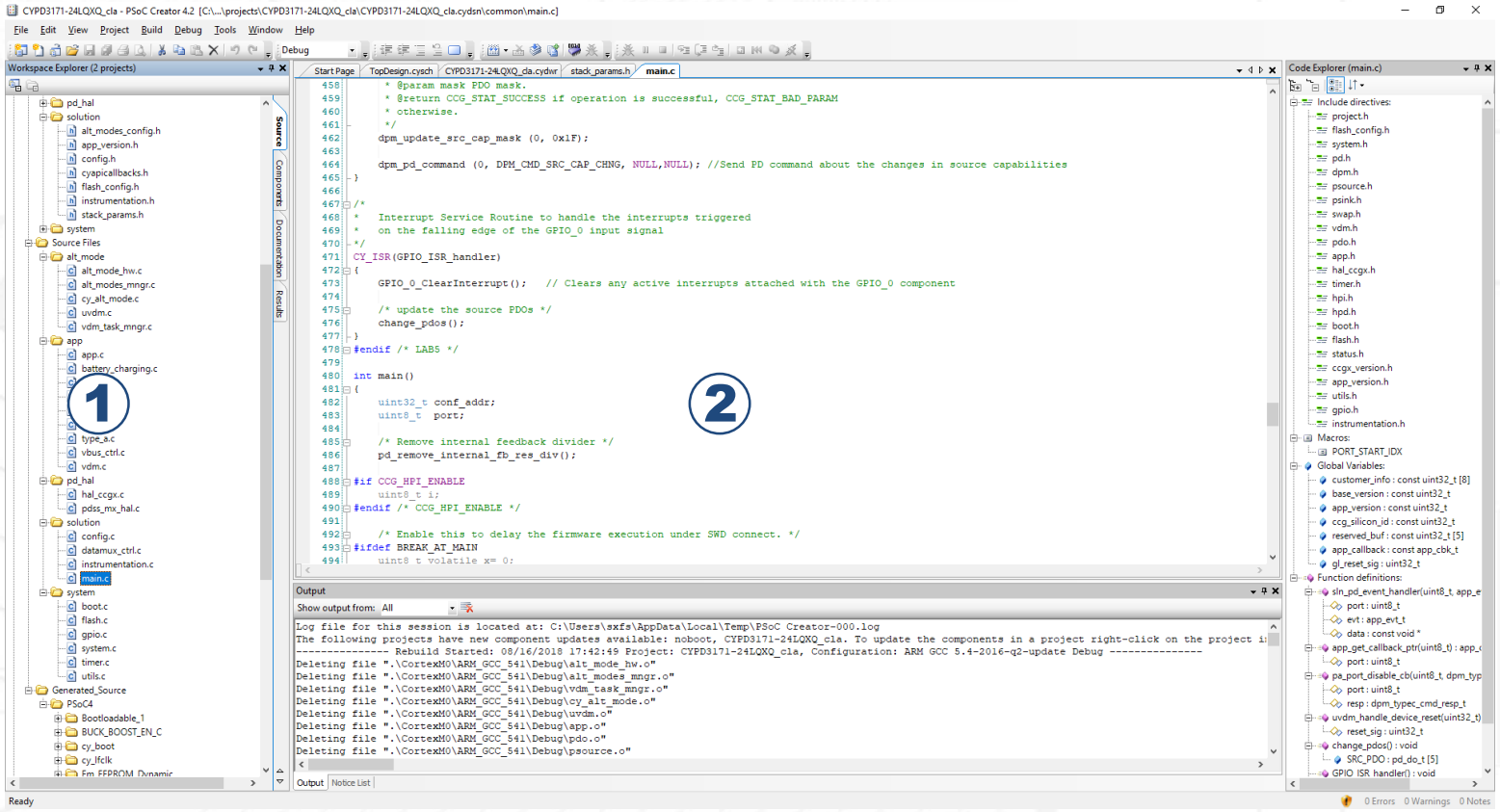
- **Demo details**
  - Change Power Adapter output power based on the status of one GPIO
  - If the GPIO is high, output power of the power adapter is 45W
  - If the GPIO is low, output power of the power adapter is 27W

  - What's the difference between 45W and 27W power adapter?
  - How to get the status of the GPIO?
  - How to tell sink devices that output power is changed?

- **Extension**
  - Type-C and Type-A Port Dynamic Adjustment
  - Temperature Based Power Throttling

Demo: EZ-PD CCGx Power Software Development Kit

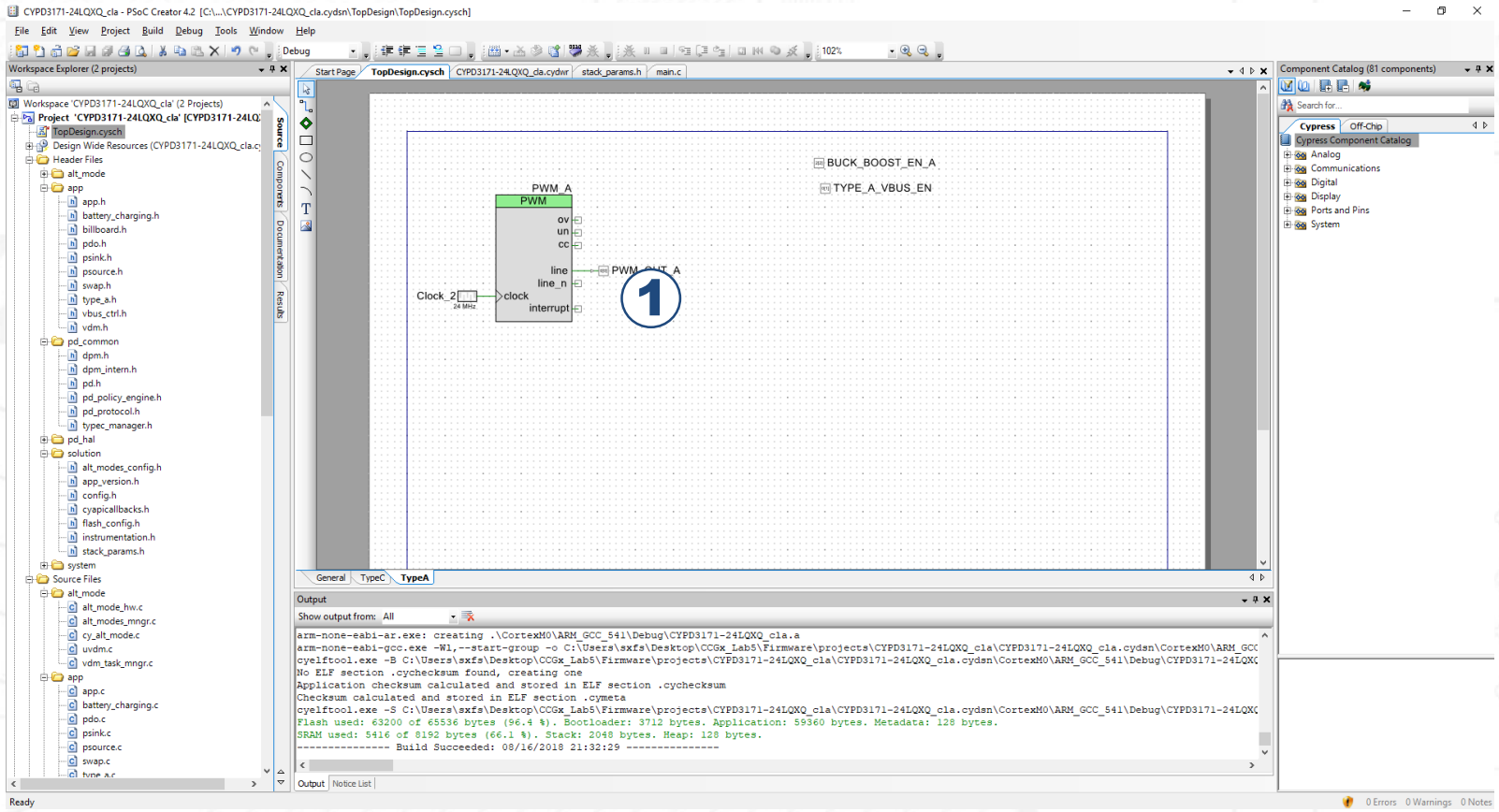
PSoC Creator IDE



1. The workspace explorer lists the active project and the various .c files included in it
2. The editor pane allows the user to modify the firmware

Demo: EZ-PD CCGx Power Software Development Kit

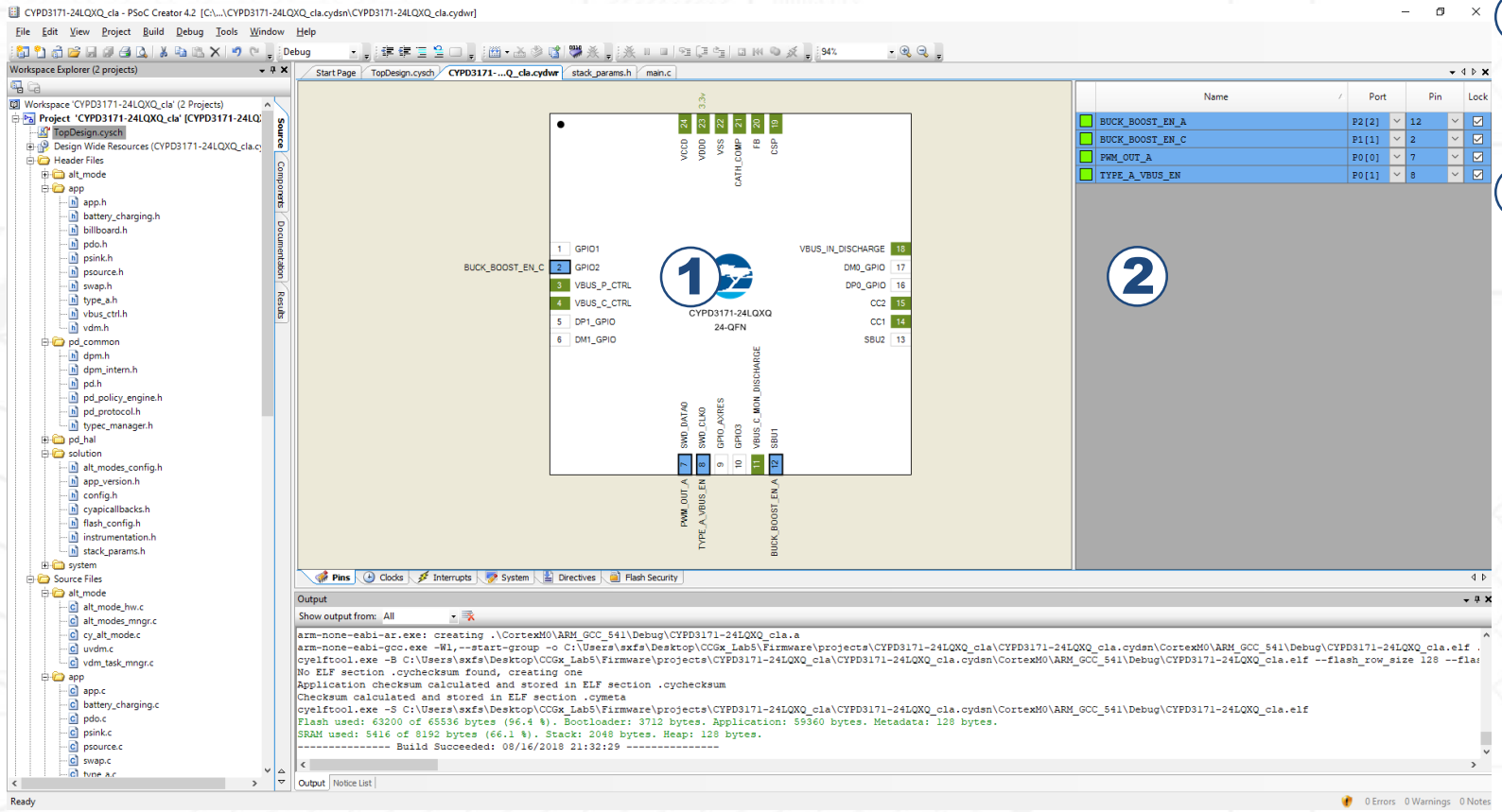
PSoC Creator Schematic View



1. The schematic view shows the internal resources in the device

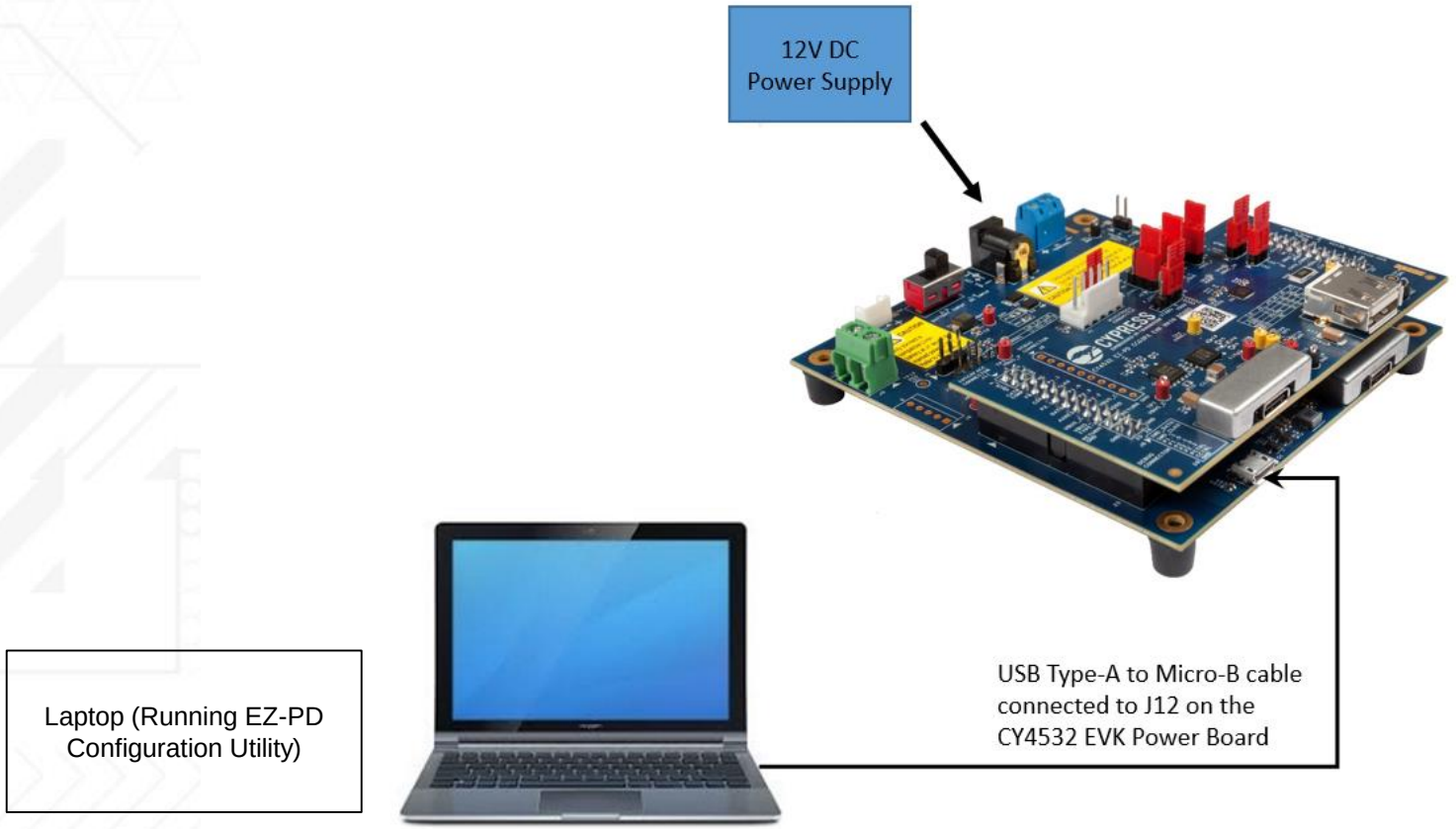
Demo: EZ-PD CCGx Power Software Development Kit

Design Wide Resource (DWR) View



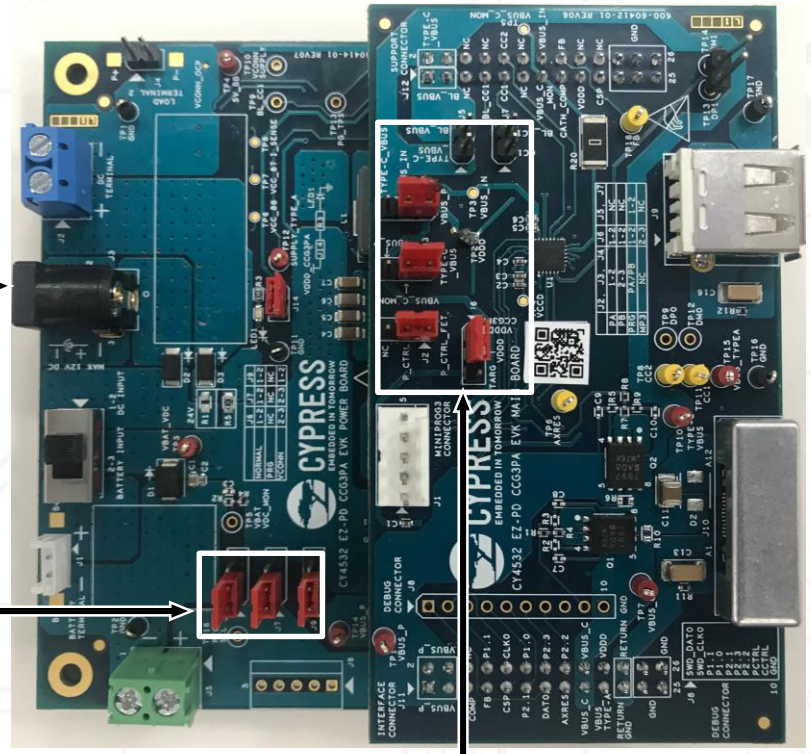
1. The DWR view shows the pin mapping for each internal resource from the schematic view
2. The pin assignments can be modified using the pin mapping table

Demo: Programming a CCG3PA with Modified Firmware



Demo: Programming a CCG3PA with Modified Firmware

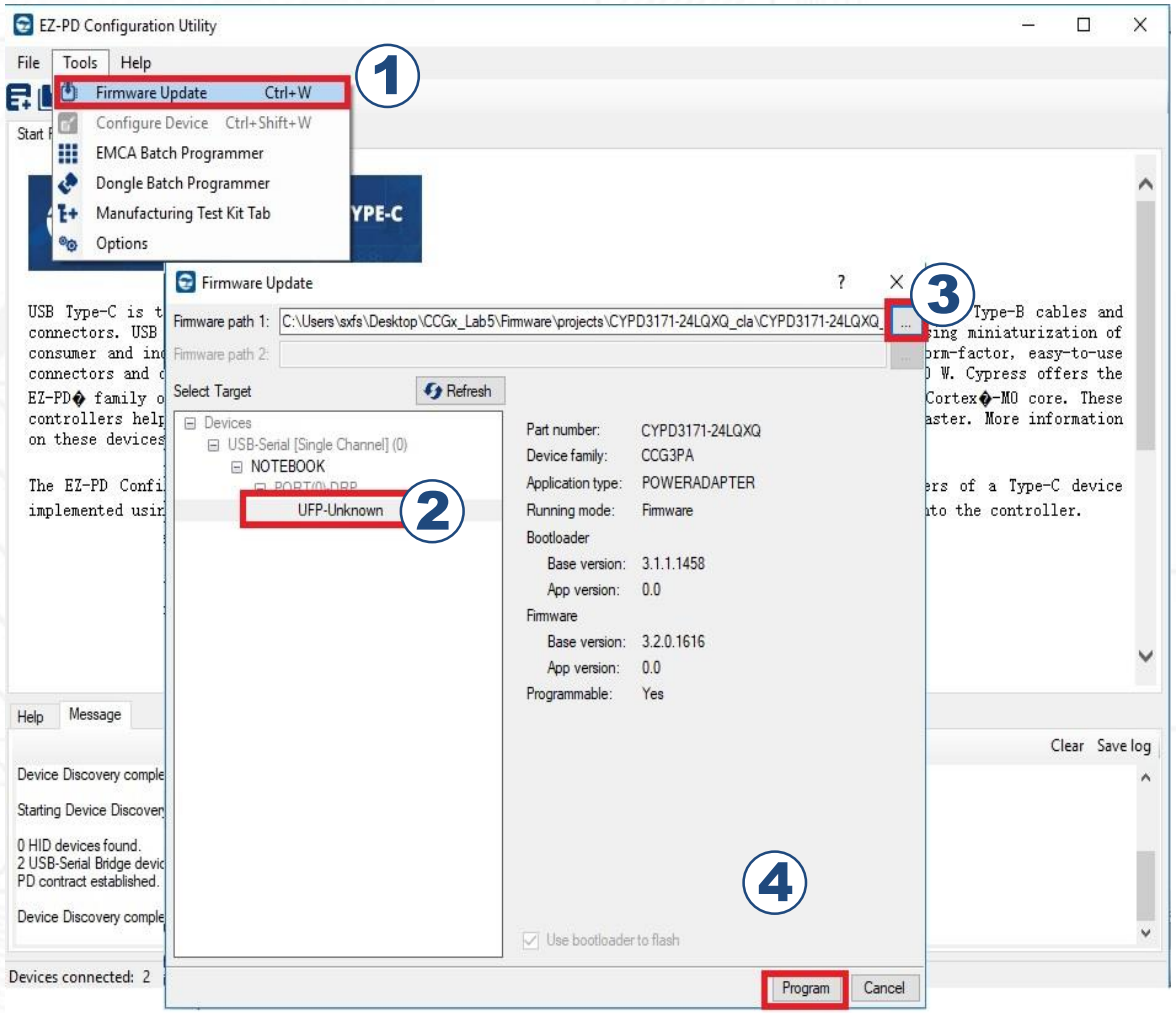
12-V DC Power Adapter



Jumper	Setting
J6	1-2
J7	1-2
J9	1-2

Jumper	Setting
J2	1-2
J3	1-2
J4	1-2
J6	1-2
J5	Open
J7	Open

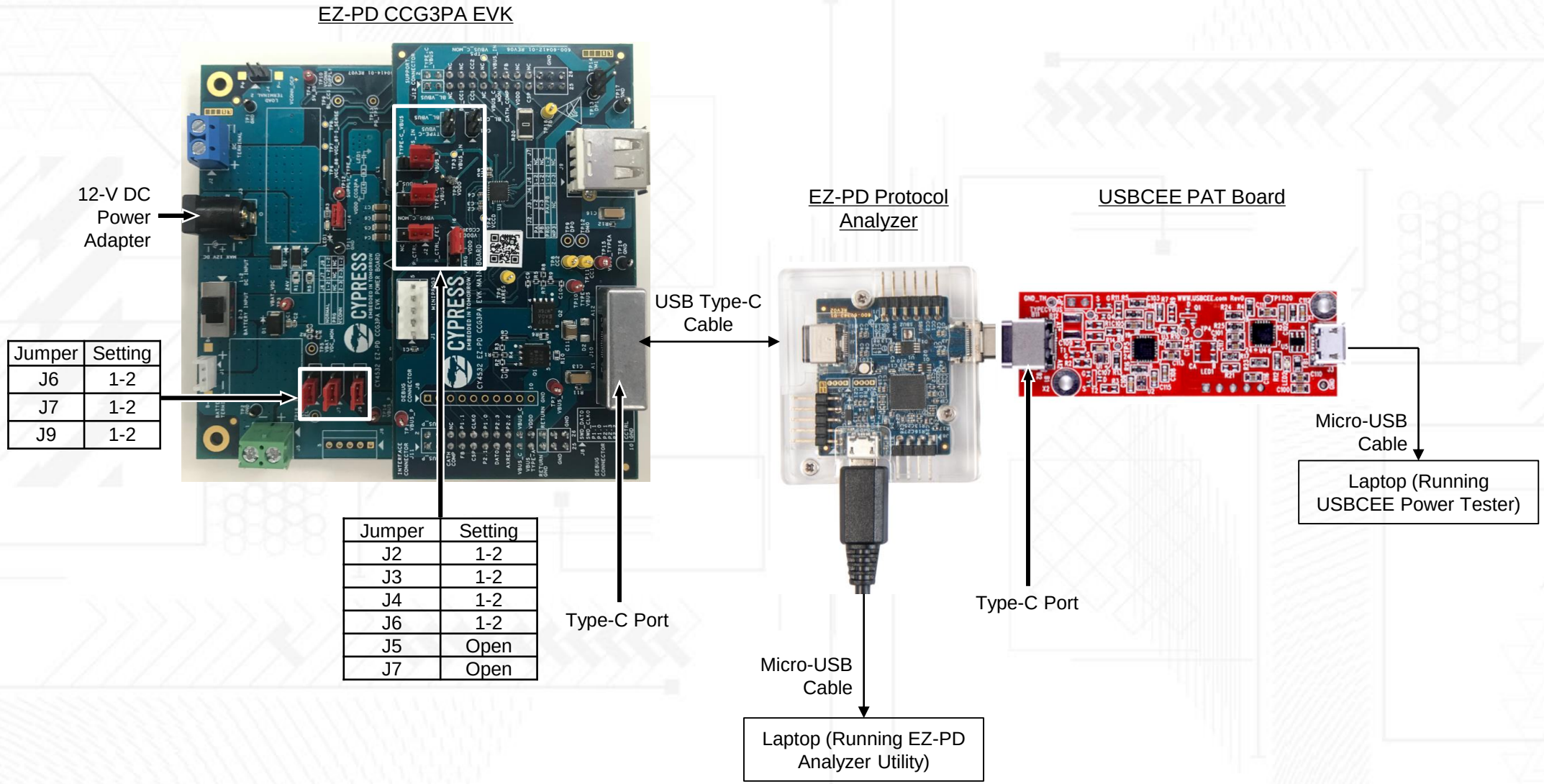
Demo: Programming a CCG3PA with Modified Firmware Using the EZ-PD Utility



Steps

1. Select **Tools** > **Firmware Update**. This opens the **Firmware Update** window.
2. Select **UFP-Unknown** as the target device
3. Select the appropriate ".cyacd" file to be programmed in folder …**\CYPD3171-24LQXQ_cla.cydsn\CortexM0\ARM_GCC_541\Debug**
4. Click on the **Program** button

Demo: Observing Modified Firmware



Debug Skills in CCG3PA Design

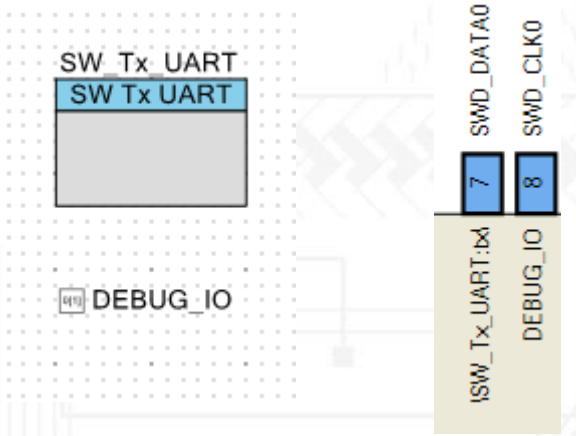
Debug Skills in CCG3PA Design

- **Add UART**
  - For all VBUS FAULT

```
#if DEBUG_UART
    SW_Tx_UART_PutString("APP_EVT_VBUS_OCP_FAULT");
    SW_Tx_UART_PutCRLF();
#endif
```

  - For special variable

```
#if DEBUG_UART
    SW_Tx_UART_PutString("ocp_cur = ");
    SW_Tx_UART_PutHexInt(ocp_cur);
    SW_Tx_UART_PutCRLF();
#endif
```




```
#define DEBUG_UART                    (1u)

#define DEBUG_IO                      (1u)
```

- **Add GPIO**
  - For function that UART can't do like

```
static void vbus_ctrl_fb_set_volt_cbk(uint8_t port, timer_id_t id)
```

```
void app_psrc_tmr_cbk(uint8_t port, timer_id_t id)
```

  - For some special timing

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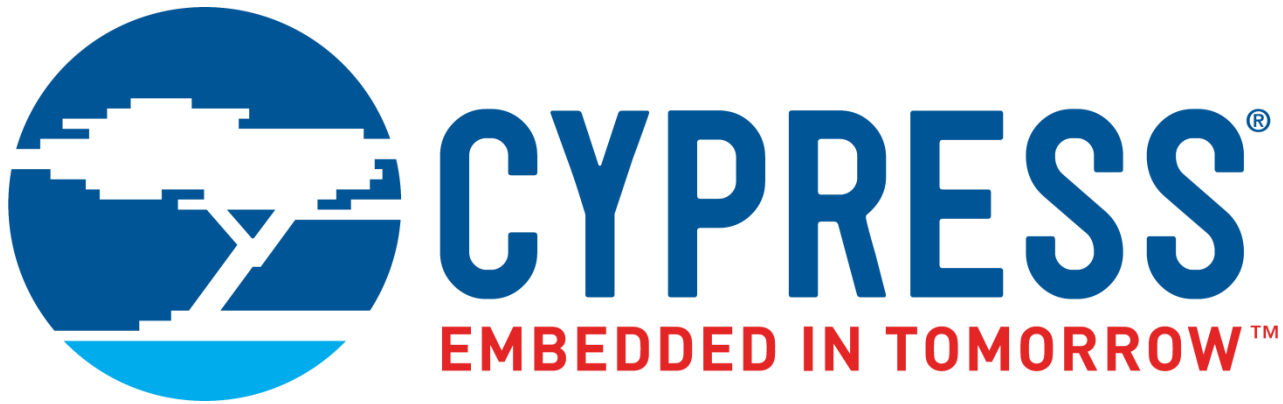
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