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Migrating the USB20H04 to the USB2504

Preface

This Application Note provides information on migrating a USB20H04 based 4-port USB 2.0 HUB design to USB2504.

1 Audience

This application note assumes that the reader is familiar with hardware design, USB protocols and USB Hubs. The goal of the application note is to provide information that allows a 4-port USB 2.0 HUB design to migrate from USB20H04 to USB2504. The migration provides system cost reduction by a reduction of external components.

2 Overview

This application note discusses considerations to design for seamless migration of a 4-port USB HUB using the currently available SMSC USB20H04 to the new SMSC USB2504. The new USB HUB USB2504 improves on the USB20H04 with additional features to give greater flexibility and lower BOM cost. The footprint for USB2504 is identical to USB20H04 in a 64-pin TQFP package. Taking the migration into account for the initial design allows the same PCB to be used after the migrating to USB2504 with BOM reduction as the only required change.

3 Feature Comparison

Functionally USB2504 is a superset of USB20H04. Additional functionality gives programmable polarity on port power control signals and strapping choices for several base configurations without the use of EEPROM or SMBUS initialization. Internal regulators eliminate the need for an external 1.8Volt regulator, thus reducing BOM cost. Both devices have a 64 pin footprint that can be used with no board layout changes. Shown in Table 3.1 below is a summary of feature.

Table 3.1 Feature Comparison USB20H04 and USB2504

FEATURE	USB20H04	USB2504
Internal 1.8V regulators	No	Yes
Programmable polarity on port power control	No	Yes
Strapping options	No	Yes
Dynamic power switching	No	Yes
OTG support	Yes	No

4 Design Considerations

There are four areas to consider for an initial design using USB20H04 to ease migration to USB2504 at a latter time. Each of the design considerations is discussed in more detail in this application note. The four areas to consider are pin definitions, regulators, EEPROM/SMBUS configuration and strapping signals.

4.1 Pin Definition Differences

The two products USB20H04 and USB2504 diverge in the pin definition for XNOR testability and power distribution. Both products have XNOR chains for continuity testing on PCBs. The differences are in the method of enabling of the XNOR test mode and the pins included in the XNOR chain. The power pin definition for USB2504 is different from USB20H04 for the internal regulators in the USB2504. The differences can be accommodated on the PCB layout to allow for complete compatibility between the two devices.

4.1.1 XNOR Chain Testing

Testing for continuity to a device with XNOR chain post assembly involves providing power to the device, enabling XNOR chain test mode, stimulating pins and checking for result on the out put of the XNOR chain. Both USB20H04 and USB2504 have XNOR chains covering all digital pins.

4.1.1.1 XNOR Chain Testing on USB20H04

Enable XNOR chain test mode by driving TEST_P0 (pin 31) high and RESET_N (pin 49) high. The output from the XNOR chain is driven to TEST_P2 (pin 33). For each pin tested for continuity TEST_P2 should toggle. Pins in the following list are not included in the XNOR chain and therefore will not effect the XNOR output. {power pins, ground pins, no-connect pins, TEST_P3, XTAL1, XTAL2, ATEST and RBIAS}.

4.1.1.2 XNOR Chain Testing on USB2504

Enable XNOR chain test mode by driving TEST (pin 31) and CFG_SEL[1] (pin 50) high, driving SCLK (pin 35) low and transition RESET_N (pin 49) from low to high. The output from the XNOR chain is driven to GR2 (pin 25). For each pin tested for continuity GR2 should toggle. Pins in the following list are not included in the XNOR chain and therefore will not effect the XNOR output: {power pins, ground pins, no-connect pins, TEST1, XTAL1, XTAL2, ATEST and RBIAS}

4.1.1.3 XNOR Chain Testing Guidelines

Table 4.1 summarizes the differences between USB20H04 and USB2504. Enabling XNOR chain test mode requires additional pins to be asserted and with different logic levels on USB2504 compared to USB20H04. The output of the XNOR chain is located on a different pin on USB2504. No-connect pins and pins not covered by XNOR chain are also different on USB2504. All three differences requires pattern and setup changes to the XNOR test program.

Table 4.1 Summary XNOR-Chain Differences Between USB20H04 and USB2504

PIN USB20H04	USB20H04 PIN NUMBER	USB20H04 STATE/FUNCTION	PIN USB2504	USB2504 PIN NUMBER	USB2504 STATE/FUNCTION
Enable XNOR pin state			**Enable XNOR pin state**		
TEST_P0	31	H	TEST	31	H
RESET_N	49	H	RESET_N	49	Transition L to H
			SCLK	35	L
			CFG_SEL[1]	50	H
TEST_P2	33	XNOR-chain Out	GR_2	25	XNOR-chain Out

Table 4.1 Summary XNOR-Chain Differences Between USB20H04 and USB2504 (continued)

PIN USB20H04	USB20H04 PIN NUMBER	USB20H04 STATE/FUNCTION	PIN USB2504	USB2504 PIN NUMBER	USB2504 STATE/FUNCTION
Pins excluded from XNOR Chain			**Pins excluded from XNOR Chain**		
NC-pin	17	No-connect	NC-pin	17	No-connect
NC-pin	18	No-connect	NC-pin	18	No-connect
VSSIO	23	Ground			
			NC-pin	32	No-connect
			NC-pin	33	No-connect
TEST_P3	48	Internal pulldown leave NC	TEST1	48	Internal pulldown leave NC
			NC-pin	56	No-connect
XTAL2	57	Not in XNOR chain	XTAL2	57	Not in XNOR chain
XTAL1	58	Not in XNOR chain	XTAL1	58	Not in XNOR chain
ATEST	62	Not in XNOR chain	ATEST	62	Not in XNOR chain
RBIAS	63	Not in XNOR chain	RBIAS	63	Not in XNOR chain
Pins with different definition on USB20H04/USB2504			**Pins included in XNOR Chain on USB2504**		
VSSIO	23	Ground	PRTPWR_POL	23	Strapping option

4.1.2 Power Pin Definitions

Power distribution to USB20H04 is divided into VDDA33 (3.3V analog), VDD33 (3.3 digital), VDDA18 (1.8V analog) and VDD18 (1.8V digital). For the USB2504 with internal regulators there is only 3.3Volts supply, however the internal regulators require external decoupling capacitors. The decoupling requirements and power distribution are discussed in the regulator section.

5 Regulator

USB20H04 requires an external 1.8Volts regulator that supplies both digital logic and analog circuitry with power. For compatibility with USB2504 without PCB layout changes, digital and analog supply pins must be separated by a component that can be populated when using USB20H04 and unpopulated when using USB2504. A ferrite bead or zero-ohm resistor can serve this purpose. Decoupling is provided by two 10uF low-ESR (below 4 ohms at 100kHz) ceramic capacitors that must be placed close to digital core supply pins and analog supply pins. One capacitor each is placed on the two supply grids. When using the USB2504 un-populate the ferrite bead or zero-ohm resistor to separate digital core supply from analog supply. The external 1.8Volts regulator must also be removed and any discrete devices required for its operation. Note that the 10uF decoupling capacitor that commonly is on the output on the 1.8Volts regulator must be retained since it will be needed by one of the internal regulators in USB2504. SMSC recommends the use of ceramic capacitors.

Two regulators internal to USB2504 supply the digital logic and analog circuitry respectively with power. Each regulator needs a good quality low-ESR (< 4 Ohms at 100kHz) 10uF capacitor to operate correctly. When using USB20H04 a ferrite bead or zero-ohm resistor is populated and the external 1.8Volts regulator supplies both the digital logic and the analog circuitry.

There are two basic configurations for supplying power using LDOs to USB20H04. One configuration places the 3.3Volts and the 1.8Volts regulators in parallel and the other configuration places the 1.8Volts regulator in series tapping off the 3.3Volts regulator. The trade-offs to choose parallel or series configuration are cost, current capabilities and power dissipation in the regulators. The following two figures illustrate the parallel and the series configuration for supplying power to USB20H04.

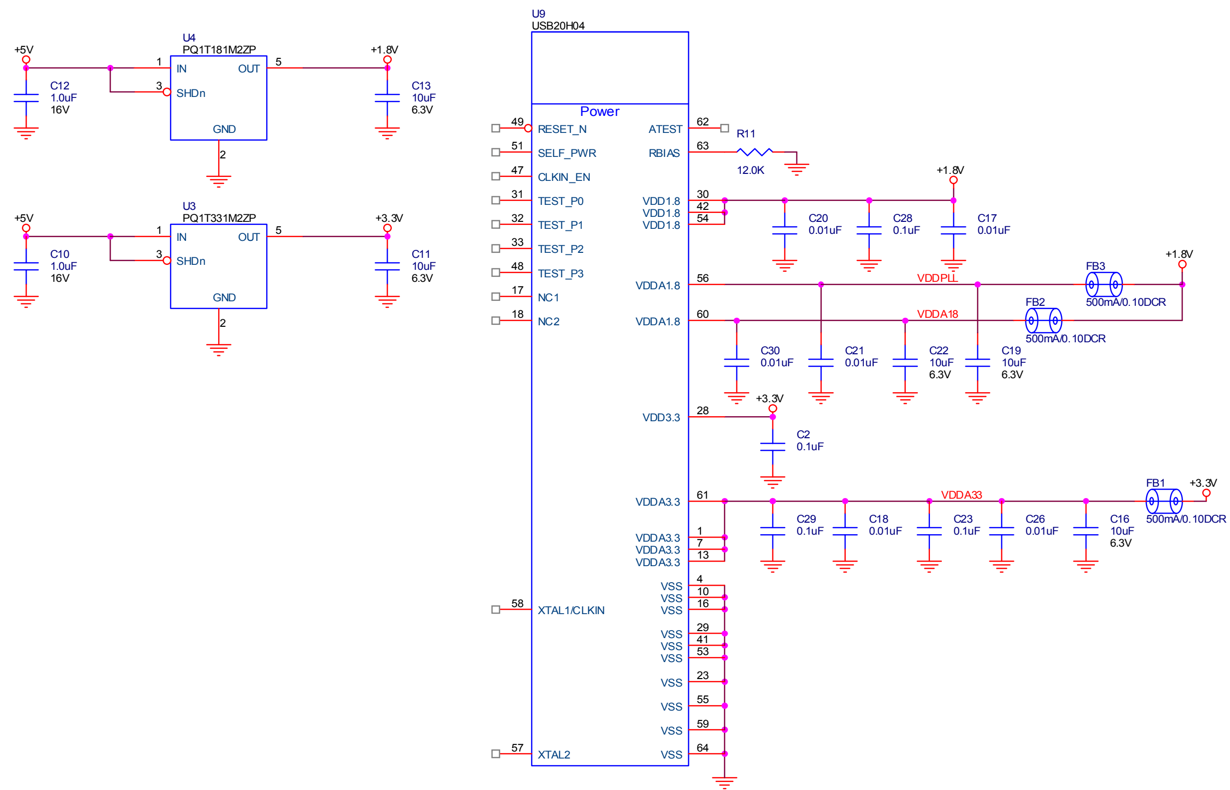

Figure 5.1 Parallel Regulator Configuration for USB20H04

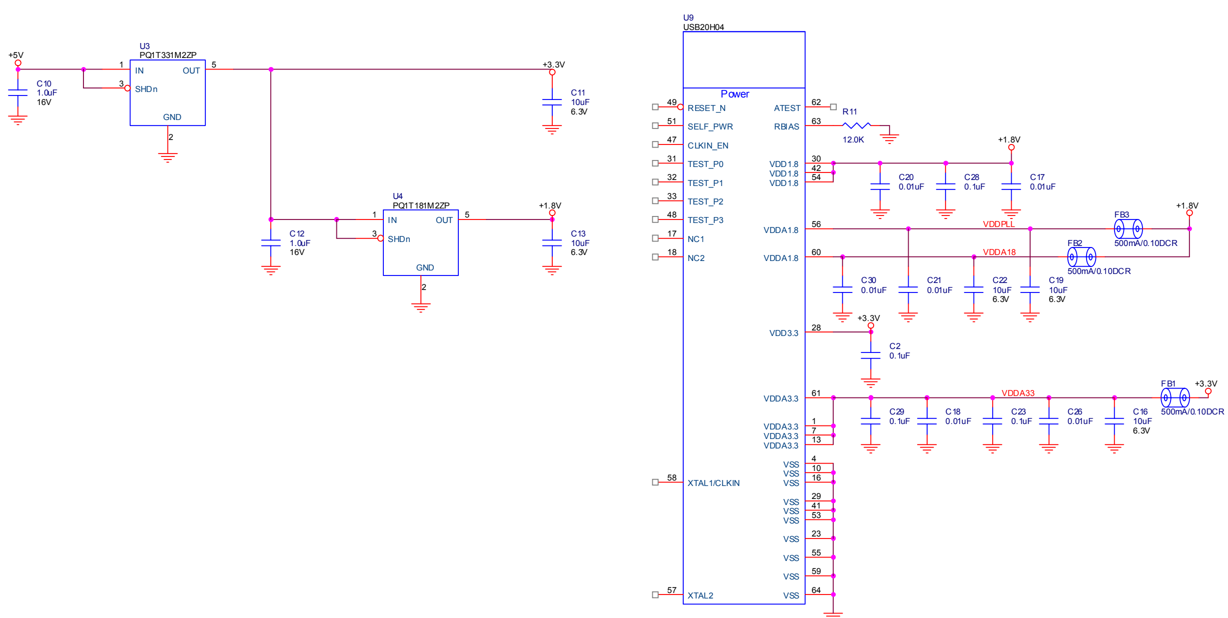

Figure 5.2 Series Regulator Configuration for USB20H04

Migrating to USB2504 on the same PCB only requires depopulating a few components thus benefiting from cost savings. Regardless of parallel or series regulator configuration the same components are depopulated when using USB2504. Figure 5.3 illustrates this for the series regulator configuration. Capacitor C13, 10uF on 1.8V power plane should be physically close to the VDD1.8 pins on USB20H04/USB2504 and must be populated for both USB20H04 and USB2504 versions.

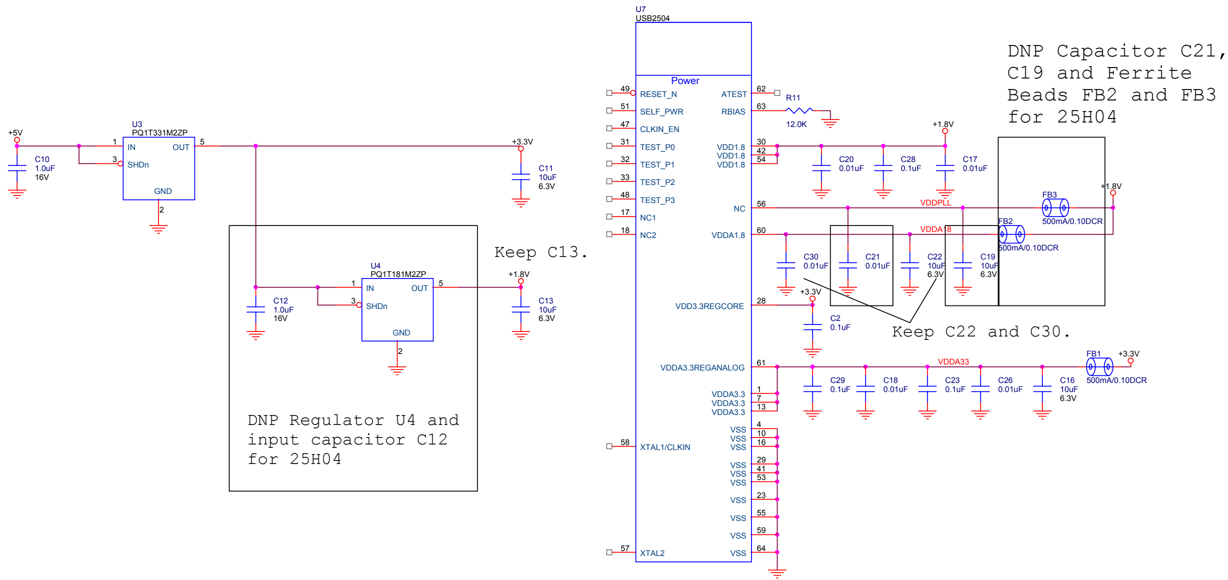

Figure 5.3 Single Regulator Configuration for USB2504 (Migrating to USB2504 allows reduction of components needed.)

In the parallel regulator configuration when migrating over to USB2504 there will be up to 130mA larger load on the 3.3Volts regulator. The requirement for decoupling on the 3.3Volts regulator depends on the total load and the manufacturer's specification. The total bulk capacitance needed for stable operation may be higher after the conversion to USB2504 and the manufacturers datasheet for the regulator should be consulted.

The additional load comes from the USB2504's internal regulators and the load from the 1.8Volts circuitry. The current consumption for USB20H04 and USB2504 are virtually the same when adding up the 3.3Volts and 1.8Volts supplies on USB20H04 versus the single 3.3Volts supply for USB2504.

The power consumption for USB2504 may increase up to 260mW (all four down-stream ports enabled and in High-Speed) above the power consumption for USB20H04. The internal regulators dissipate the additional power when regulating down from 3.3 Volts to 1.8 Volts. No additional considerations are required for most applications using four layer PCBs. If a 2 layer PCB is used ground or VDD pours should extend inside the boundary of the footprint for USB20H04/USB2504 to allow heat to diffuse on the PCB.

6 EEPROM/SMBUS Initialization Considerations

The EEPROM/SMBUS configuration information is expanded for USB2504. There are additional data bytes as well as differences in byte ordering and individual bits between USB20H04 and USB2504. SMBUS registers definitions are identical to the EEPROM registers. Configuration registers are located at starting address 0 for EEPROM and starting at 1 for SMBUS. SMBUS location 0 is a control register and has the same definition for USB20H04 and USB2504.

Table 6.1 Comparison of EEPROM/SMBUS Address Space Between USB20H04 and USB2504

EEPROM LOCATION / SMBUS ADDRESS	USB20H04 DEFINITION	USB2504 DEFINITION	DIFFERENCES
0 / 1	VID Most Significant Byte	VID Least Significant Byte	Byte order
1 / 2	VID Least Significant Byte	VID Most Significant Byte	
2 / 3	PID Most Significant Byte	PID Least Significant Byte	Byte order
3 / 4	PID Least Significant Byte	PID Most Significant Byte	
4 / 5	DID Most Significant Byte	DID Least Significant Byte	Byte order
5 / 6	DID Least Significant Byte	DID Most Significant Byte	
6 / 7	Config Data 3 –	CONFIG_BYTE_1	Bits 2:0 - Current sense, Port Power and Compound Device
7 / 8	Config Data 2	CONFIG_BYTE_2	Bits 7:0 – Non-Removable Device, Disabled Ports and Over Current Timer
8 / 9	Config Data 1	Non-Removable Device	Bits 7:0 - Dynamic Power and OTG
9 / 0A	Max Current	Port Disable for Self Power Operation	USB2504 has two values: bus power (0C) and self power (0B)
0A / 0B	Hub Controller Current	Port Disable for Bus Power Operation	USB2504 has two values: bus power (0E) and self power (0D)
0B / 0C	Power-on Time	Max Current for Self Power Operation	USB2504 moved to location 0F
0C / 0D	Not Used	Max Current for Bus Power Operation	
0D / 0E	Not Used	Hub Controller current Self Power	
0E / 0F	Not Used	Hub Controller Current Bus Power	
0F / 10	Not Used	Power-On Time	
10 … / 11 …	Not Used	Not Used	

Table 6.2 Differences in Definition of Individual Bits for EEPROM Location 6, SMBUS Location 7

BIT	USB20H04 CONFIG DATA 3	USB2504 CONFIG_BYTE_1	DIFFERENCES
2	Current Sensing – 0 = Individual 1 = Ganged	Current Sensing[1] – 0 = Enabled and Bit 1 determines configuration 1 = Disabled (Bus Power operation)	USB20H04 has one bit to select individual or ganged current sense. USB2504 has two bits – Bit 2 determines of current sense is available and Bit 1 selects individual or ganged current sense. Note polarity difference for selection
1	Port Power Control – 0 = Individual 1 = Ganged	Current Sensing[0] – If Bit 2 = 0 0 = Ganged 1 = Individual	USB2504 has same functionality as USB20H04. The location of Port Power Control has moved to bit 0 on USB2504
0	Compound Device – 0 = Not compound device 1 = HUB is part of a compound device	Port Power Control – 0 = Ganged 1 = Individual	Compound Device selection has moved to CONFIG_BYTE_2, bit 3 on USB2504

Table 6.3 Differences in Definition of Individual Bits for EEPROM Location 7, SMBUS Location 8

BIT	USB20H04 CONFIG DATA 2	USB2504 CONFIG_BYTE_2	DIFFERENCES
7	1 = Port 4 is non-removable	Dynamic Power Enable – 0 = No Dynamic auto-switching 1 = Dynamic Auto-switching capable	Non-removable configuration bits are placed in Non-removable device location (08) in USB2504
6	1 = Port 3 is non-removable		
5	1 = Port 2 is non-removable	Over Current Timer[1]	
4	1 = Port 1 is non-removable	Over Current Timer[0]	
3	1 = Port 4 is disabled	Compound Device – 0 = No 1 = Hub is part of a compound device	Disabled port configuration bits are split into bus power and self power operation and located in (09) and (0A) respectively in USB2504
2	1 = Port 3 is disabled	Reserved – 0	
1	1 = Port 2 is disabled	Reserved – 0	
0	1 = Port 1 is disabled	Reserved - 0	

Table 6.4 Differences in Definition of Individual Bits for EEPROM Location 8, SMBUS Location 9

BIT	USB20H04 CONFIG DATA 1	NON-REMOVABLE DEVICE	DIFFERENCES
7	Reserved - 0	Reserved – 0	
6	On-The-GO (OTG) support enable – 0 = OTG Disabled 1 = OTG Enabled	Reserved – 0	
5	Reserved – 0	Reserved – 0	
4	Reserved – 0	1 = Port 4 is non-removable	
3	Over-Current Timer[3]	1 = Port 3 is non-removable	Over Current Timer is reduced to 2 bits located in CONFIG_BYTE_2 location (07) bits [5:4] in USB2504. Timer delay choices are the same as for USB20H04 {0.1ms, 2ms, 4ms or 6ms}
2	Over-Current Timer[2]	1 = Port 2 is non-removable	
1	Over-Current Timer[1]	1 = Port 1 is non-removable	
0	Over-Current Timer[0]	Reserved - 0	

7 Default Configuration

There are two default configurations of USB20H04 when not using external EEPROM or SMBUS initialization: self-powered or bus-powered operation. In self-powered configuration all four ports are enabled with individual port power control and individual port over current detection. In bus-powered configuration three ports are enabled (port 4 is disabled), individual port power control and individual port over current detection. SMSC USB2504 expands on the number of configurations selectable by strapping pins, sampled at hardware reset. The configurations include polarity on port power control signals, Single-TT or Multi-TT, individual or ganged port power control, individual or ganged over current sensing, enabled/disabled LED indicator.

7.1 Configuration Without EEPROM and SMBUS Initialization

7.1.1 Default Configuration for USB20H04

There are two default configurations for USB20H04. Default configuration is enabled by pulling SMB_SEL_N (pin 50) high and pulling CS/EESEL (pin 36) low. The state of SELF_PWR when RESET_N is negated (low to high transition) selects which of the two configurations to load. If SELF_PWR is asserted (high) the self-power default configuration is used and if SELF_PWR is negated (low) the bus-power default configuration is selected.

7.1.1.1 SELF Power Case

USB20H04 is configured with VID = 0424, PID = A700, individual over current sense and port power control, SELF powered, LEDs enabled, dynamic power switching disabled and port power on time is 256 ms (80 hex).

7.1.1.2 BUS Power Case

USB20H04 is configured with VID = 0424, PID = A700, BUS powered, individual over current sense and port power control, LEDs disabled, port 4 disabled, dynamic power switching disabled, max power = 200mA (64 hex), hub controller power = 200mA (64 hex) and port power on time is 256 ms (80 hex).

7.1.2 Default Configuration for USB2504 with No Strapping Options

SMSC USB2504 has a no strap default option. When CFG_SEL2 (pin 59) is negated (low) no other strap options are available to USB2504. Pin 59 is identified as VSSIO on USB20H04 and must be grounded for it. This configuration requires no other BOM changes for USB2504 to stay compatible with USB20H04.

7.1.2.1 SELF Power Case

Table 7.1 Externally Visible Differences Between USB20H04 and USB2504

DESCRIPTION	USB20H04	USB2504
PID	A700	2504
Dynamic Power Switching	Disabled	Enabled
LED Indicators	Disabled and reported not present	Enabled but reported not present
Power-on Time	256 ms (80hex)	100 ms (32hex)

7.1.2.2 BUS Power Case

Table 7.2 Externally Visible Differences Between USB20H04 and USB2504

DESCRIPTION	USB20H04	USB2504
PID	A700	2504
Dynamic Power Switching	Disabled	Enabled
Power-on Time	256 ms (80hex)	100 ms (32hex)
Available down stream ports	3	4

8 Configuration of USB2504 with Strapping Options

Default configurations enabled by strapping choices can in some cases eliminate the need for an external EEPROM or SMBUS initialization. In particular, if the design has one or more ports disabled, is part of a compound device with non-removable ports, BOM options for port power control, over current sense and LED indicators, it is possible to select the appropriate configuration with straps. If the initial design uses 20H04 and EEPROM for configuration, then when migrating to USB2504 the EEPROM is removed and resistors are moved to select an equivalent configuration.

8.1 Enabling Strapping Options on USB2504

Default configuration is enabled for USB2504 by pulling CFG_SEL2 (pin 59) and CFG_SEL1 (pin 50) high and pulling CFG_SEL0 (pin 36) low. CFG_SEL2 does not exist on USB20H04. Instead pin 59 is VSSIO on USB20H04. CFG_SEL1 and CFG_SEL0 are equivalent to CS/EESEL and SMB_SEL_N on USB20H04. The specific configuration for USB2504 is determined by several strapping options selected by weakly pulling pins either high or low during reset. The state of SELF_PWR effects the configuration similarly to USB20H04. After reset the configuration is locked and only a new reset will reconfigure the hub. The strapping options are listed here:

1. Individual or Ganged over current sense and port power switching
2. Polarity on port power control signals (active high or active low) - USB20H04 is always active low
3. Single-TT or Multi-TT – USB20H04 is always Multi-TT

4. LED indicators reported present/not present – USB20H04 always enabled for self power and always disabled for bus power
5. Non-removable ports (3, 2 and 3, or 1, 2 and 3) – USB20H04 all ports are removable
6. Disabled ports (4, 3 and 4, or 2, 3 and 4) – USB20H04 all ports enabled for self power and port 4 disabled for bus power
7. Internal regulators disabled/enabled – USB20H04 does not have internal regulators

8.2 Configurations Where Strapping Can Eliminate EEPROM

The most common case where migrating to USB2504 can eliminate the need for an external EEPROM is for compound devices. A compound device incorporates a USB hub and one or more additional USB devices. Examples of compound devices are keyboards with built-in hubs and card readers with built-in hubs. When the hub is used in compound device one or more ports are declared non-removable. These ports are permanently attached to the built-in USB devices. Ports 1, 2 and 3 can be used for built-in devices with strapping option to correctly configure the hub. In addition if one or more ports are unused it is possible to disable ports 4, 3 and very unlikely port 2 with strapping options. For details on strapping configurations please consult the SMSC USB2504 data sheet.

In Figure 8.1 an example is shown of USB2504 for one strapping pin GR1 with a single location for the LED. Two resistors are placed in one of two locations to choose pull low or pull high. If no LED indicator is needed the circuit can be replaced by a single 100k resistor from GR1 that is either tied to 3.3Volts or ground. The same basic circuit is repeated for GR2, GR3, GR4, AM1, AM2 and AM4 pins. Note for USB20H04 only pull high option can be used. All LED indicator signals on USB20H04 are active low.

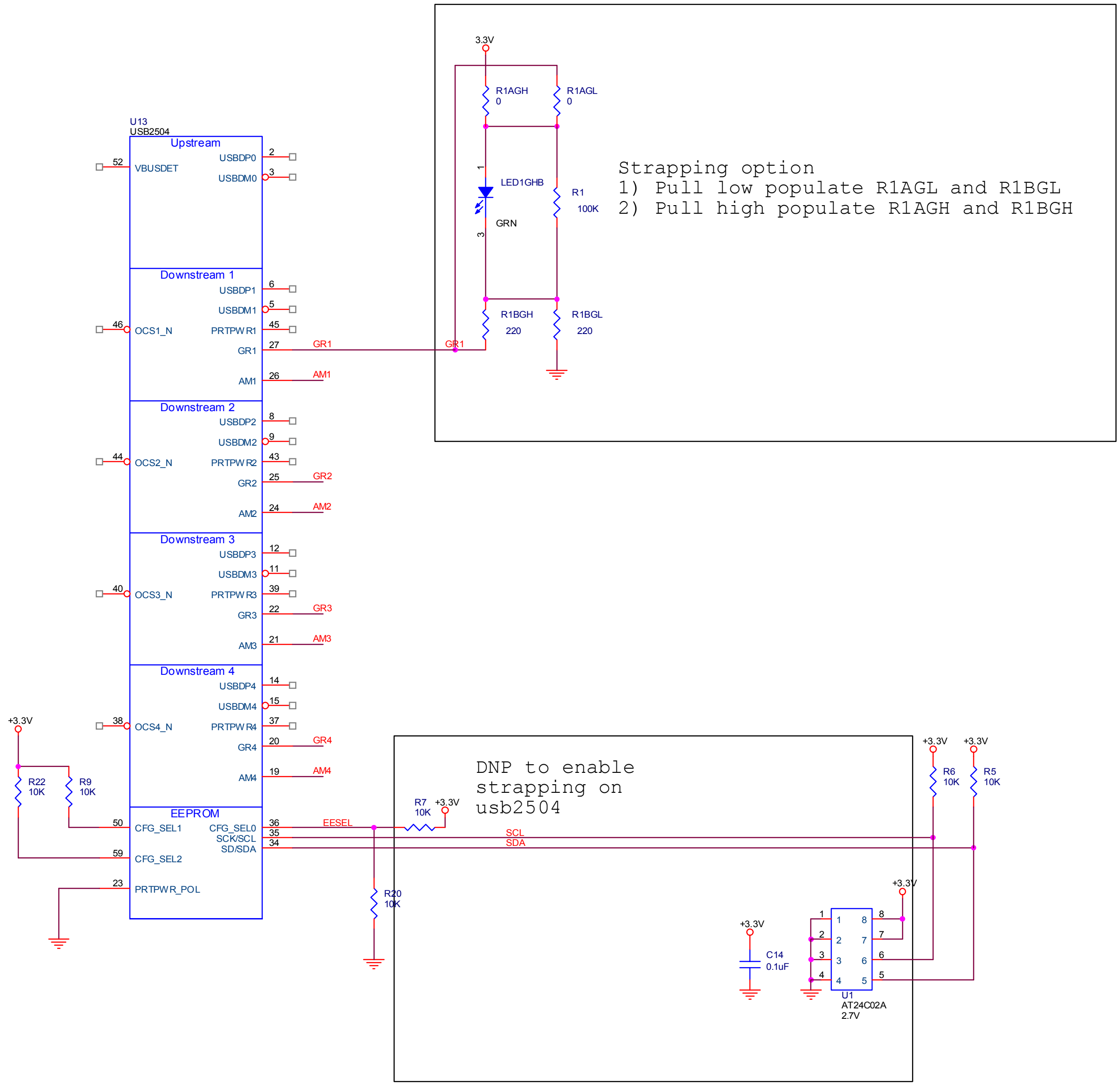

Figure 8.1 Example of USB2504 Strapping Implementation for Pin GR1 (The same resistor bridge with LED is replicated for GR2-GR4, AM1, AM2 and AM4.)

8.3 Differences Between USB20H04 and USB2504 Not Effected by Straps

Default configuration differences to USB20H04 that are not changeable by strapping options for SELF power

1. PID = 2504 – USB20H04 is A700
2. Dynamic power switching enabled
3. Max power 2mA (01 hex)
4. Hub power 2ma (01 hex)
5. Power on time 100ms (32 hex)

Default configuration differences to USB20H04 that are not changeable by strapping options for BUS power

1. PID = 2504 – USB20H04 is A700
2. Over current sense disabled
3. Dynamic power switching enabled
4. Power on time 100ms (32 hex)

8.3.1 SELF Power Strapping Choices on USB2504 Compatible with USB20H04

1. Individual over current sense and port power switching – pull AM1_P/N low
2. Active low port power control – pull PRTPWR_POL low
3. Enable Multi-TT – pull AM2_P/N high
4. Enable LED indicators – pull AM4_P/N high
5. All ports removable – pull GR1_N and GR2_N high
6. All ports enabled – pull GR3_N and GR4_N high

8.3.2 BUS Power Strapping Choices on USB2504 Compatible with USB20H04

1. Individual port power switching – pull AM1_P/N low
   Over current sense is disabled in BUS power
2. Active low port power control – pull PRTPWR_POL low
3. Enable Multi-TT – pull AM2_P/N high
4. Disable LED indicators – pull AM4_P/N low
5. All ports removable – pull GR1_N and GR2_N high
6. Disable port 4 – pull GR3_N low and GR4_N high

8.4 SELF Power Configuration with BUS Power Operation

There are two special cases when the HUB is configured for SELF power mode and continues to operate if self power is removed by tapping into USB cable power on the upstream port.

Case 1: SELF_PWR does not change

When the state of pin SELF_PWR does not change. The behavior and configuration for both USB20H04 and USB2504 remain identical.

Case 2: SELF_PWR changes state

When SELF_PWR is asserted when external power is supplied, i.e. from a wall-plug supply, and negated when the external power is removed, and the HUB remains powered from the USB cable on the upstream port. In this case the USB20H04 does not change configuration. It remains unchanged with the exception that in its hub descriptor it will reflect that the hub is currently bus powered. All ports remain operational and all other descriptor values remain the same.

USB2504 on the other hand will detach, reset and read all strapping options and select BUS power configuration. Thereafter it will reattach to the host.

80 Arkay Drive
Hauppauge, NY 11788
(631) 435-6000
FAX (631) 273-3123