

Power Distribution for the MMM6007 Module

by: Power Management and Audio Application Team

1 Introduction

The purpose of this application note is to provide general guidelines for the implementation of the Melody Vdd core voltage (VMelody core) on a radio design.

The Melody core voltage supplies the following:

- Approximately 700k gate equivalents of digital standard cell logic. This includes Rx, Tx, and synthesizer sections. Approximately 12 mA of current in full duplex mode at 1.2 V or 18 mA at 1.6 V, forcing large digital switching current impulses.
- A 26 MHz clock synthesizer TCXO input buffer. Supply noise significantly contributes to spur induced deterministic jitter. This clock is used as reference for 92.16 MHz PLL, which is the main clock source for all blocks within the design.
- All level shifters that interface between the 1.2 V digital and 2.7 V analog design blocks. This includes the Tx modulation sigma delta DACs that are very sensitive to supply noise induced deterministic jitter.

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2 PCB Layout Recommendation

Routing is always the top priority for any trace. The same should be isolated from noisy traces like clocks and RF lines. Adequate amount of decoupling capacitors should be placed as close as possible to the source and destination pins. Wide trace should be used for the DC distribution to provide current flow capability with minimal resistive loss. The source for the Melody Vdd core voltage should not be used to power any other circuit as to avoid adding any noise to the line. Additional decoupling consideration will be required to suppress any electrical noise unique to a product implementation. [Figure 1](#) shows the recommended implementation of the PCB and [Figure 2](#) shows the implementation concerns.

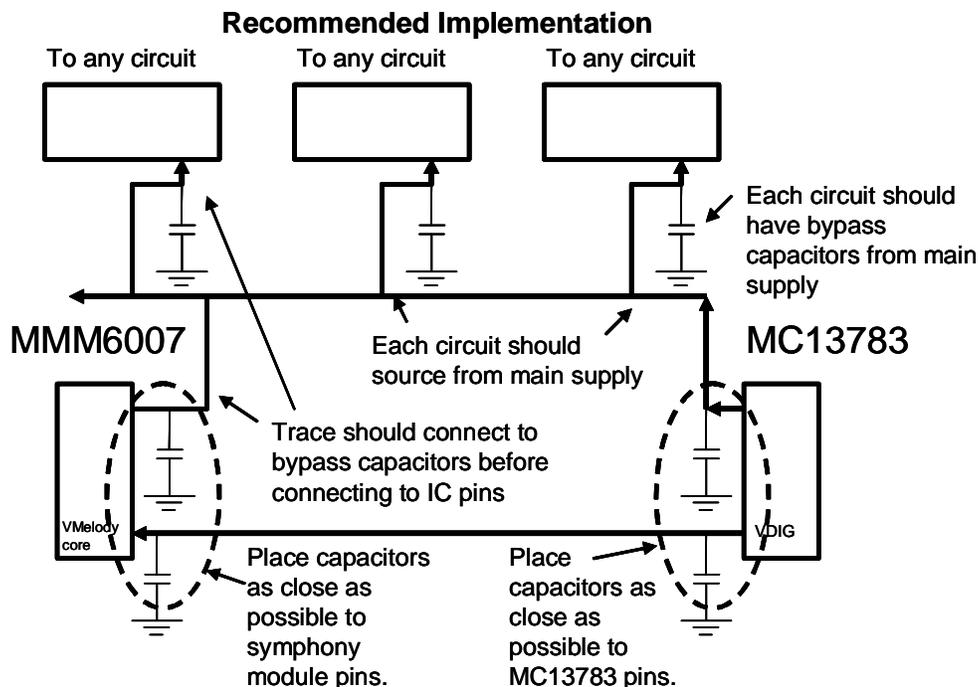


Figure 1. Recommended PCB Layout

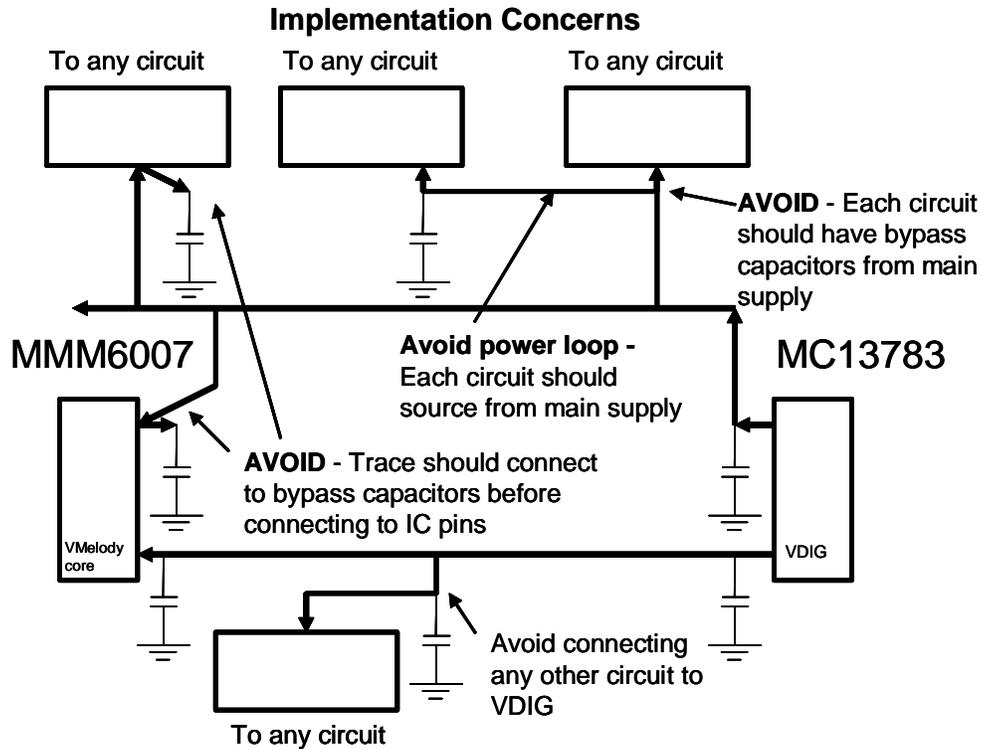


Figure 2. PCB Implementation Concerns

3 Selection of Bypass Capacitors

Refer to Freescale's *MC13783 Data Sheet* (Document Number: MC13783) for the recommended minimum bypass capacitance value for each regulator and buck switchers. [Table 1](#) is a list of the power supplies used by the MMM6007 and the Freescale recommended implementation. All effort must be made to minimize variations of ceramic capacitors.

Variations of ceramic capacitors depend of three main parameters:

- Tolerance (generally 10% or 20%). Avoid using 20% parts since these parts will force the implementation of additional parts to meet minimum required capacitance value.
- Temperature (15% for X5R and X7R).
- DC Bias (from 0% up to 80%). Since DC bias is mostly a function of physical size it is recommended that the largest possible parts are used.

Table 1. MC13783 Recommended Capacitor Implementation

Block	DTS Value (uF)		Case	Freescale Recommendation
	Typical	Minimum		
VIOHI	1	0.65	0402	C1005X5R0J105K
VRFREF	1	0.65	0402	C1005X5R0J105K or C1608X5R0J225M To increase noise performance
VRFCP				

Table 1. MC13783 Recommended Capacitor Implementation (continued)

Block	DTS Value (uF)		Case	Freescale Recommendation
	Typical	Minimum		
VDIG	2.2	1.43	0603	C1608X5R0J225K or C2012X5R1A225K
VREFDIG				
VRF1	2.2	1.43	0805	C2012X5R1A225K or C1608X5R0J475M
VRF2				
SWxA	22 + 2.2	14.3	0805	C2012X5R0J226MTJ in // C1608X5R0J225M or only one C3225X5R1C226M
SWxB	22 + 2.2	14.3	0805	C2012X5R0J226MTJ in // C1608X5R0J225M or only one C3225X5R1C226M
SW1 or SW2 Parallel	2 x 22 + 2.2	28.6	0805 and 0603	C2012X5R0J226MTJ in // C1608X5R0J225M

4 VDig Regulator Decoupling Capacitor Study

Table 2 shows the minimum bypass capacitor value at the MC13783 pin for the VDIG regulator is 2.2 uF (-35%) = 1.43 uF. There are several choices for design depending on procurement practice and/or mechanical size requirements. For situations where the procurement part number corresponds to a single vendor part number the designer could specify C1608X5R0J225K (0603 from TDK) or JMK107BJ225KA (0602 from Taiyo Yuden). Taking into account the variations (as shown in Figure 3), the actual capacitance is 1.46 uF or 1.52 uF depending on vendor used. Worst case capacitance in this case would be above the minimum value recommended.

For situations where multiple vendor part numbers are associated with a single procurement part number there is the possibility of having a 0603 part below the minimum recommended value such as C1608X5R0J225M (0603 from TDK) or GRM188R61A225M (0603 from Murata). Taking into account the variations (as shown in Figure 3), the actual capacitance range is between 1.30 uF and 1.52 uF depending on vendor used. The performance variation on a product for this range could be interpreted as “lot-to-lot” variations when a reel of parts is changed in production. Worst case capacitance in this case would be below the minimum value recommended. In this case, the designer should specify two 0603 parts or one 0805 part to meet the minimum recommended value.

Table 2. MC13783 Regulator General Characteristics

Parameter	Condition	Min	Typ	Max	Units
Operating Input Voltage Range Vinmin to Vinmax		Vnom + 0.3		4.65	V
Output Voltage Vout	Vinmin < Vin < Vinmax ILmin < IL < ILmax	Vnom - 3%	Vnom	Vnom + 3%	V
Load Regulation	1mA < IL < ILmax For any Vinmin < Vin < Vinmax			0.20	mV/mA
Active Mode Quiescent Current	Vinmin < Vin < Vinmax IL = 0		20	30	µA

Table 2. MC13783 Regulator General Characteristics (continued)

Parameter	Condition	Min	Typ	Max	Units
Low Power Mode Quiescent Current	Vinmin < Vin < Vinmax IL = 0		5	10	μA
PSRR	IL = 75% of ILmax 20 Hz to 20 kHz Vin = Vnom + 1V	50	60		dB
Minimum Bypass Capacitor Value	Used as a condition for all other parameters	-35%	2.2	+35%	μF
Bypass Capacitor ESR	10 kHz - 1 MHz	0		0.1	Ω

Figure 3 gives the minimum capacitor value regarding process (10 or 20%), temperature (15%) and DC bias variation.

Capacitor (uF)	Case	Supplier	Part Number	2V range	3V range	4.2V range	5.5V range
0.1	0201	TDK	C0603X5R0J104M	0.061	0.055	0.046	0.037
0.1	0402	TDK	C1005X7R1C104K	0.074	0.072	0.068	0.064
0.1	0603	TDK	C1608X7R1H104K	0.077	0.077	0.077	0.077
1.0	0402	TDK	C1005X5R0J105K	0.64	0.52	0.41	0.29
1.0	0603	TDK	C1608X5R1C105K	0.76	0.73	0.67	0.62
1.0	0805	TDK	C2012X5R1E105M	0.68	0.68	0.67	0.65
2.2	0603	TDK	C1608X5R0J225M	1.30	1.11	0.84	0.61
2.2	0603	TDK	C1608X5R0J225K	1.46	1.25	0.94	0.69
2.2	0603	Murata	GRM188R61A225M	1.35	1.18	0.97	0.75
2.2	0603	Taiyo Yuden	JMK107BJ225KA	1.52	1.35	1.13	0.93
2.2	0805	TDK	C2012X5R1A225K	1.65	1.62	1.50	1.40
2.2	0805	TDK	C2012X5R1E225K	1.68	1.65	1.62	1.55
4.7	0603	TDK	C1608X5R0J475M	2.69	2.33	1.92	1.47
10	0603	TDK	C1608X5R0J106M	5.98	5.30	4.42	3.60
10	0805	TDK	C2012X5R0J106M	5.58	4.62	3.67	2.86
10	0805	TDK	C2012X5R1A106M	6.32	5.85	5.17	4.56
22	0805	TDK	C2012X5R0J226M	10.32	7.03	4.79	3.44
22	0805	TDK	C2012X5R0J226V	11.61	7.91	5.39	3.87
22	0805	TDK	C2012X5R0J226MTJ	13.61	11.97	10.02	8.23
22	0805	Murata	GRM21BR60J226M	12.12	10.17	7.63	5.98
22	0805	Taiyo Yuden	JMK212BJ226MG	12.12	9.87	7.48	5.69
22	1206	TDK	C3216X5R0J226M	13.91	12.57	10.92	8.98
22	1210	TDK	C3225X5R1C226M	14.36	14.06	13.02	11.52

Orange colored are capacitors used on EVB. Red colored are capacitors having a height > 1.5mm.

Figure 3. Summary Capacitor Guide Table

5 Buck Switcher 2 Decoupling Capacitor Study

Since Vdig is supplied by buck switcher 2, the similar part specification consideration needs to take place.

Table 3 shows the minimum bypass capacitor value at the MC13783 pin per buck switcher is 22 uF (-35%) = 14.3 uF. There are two choices for this implementation based on commercially available parts: one 1210 part or two 0805 parts (one 22 uF and one 10 uF). Taking into account the variations (as shown in Figure 3), the actual capacitance range for a 0805, 22 uF capacitor is between 10.32 uF and 13.61 uF and for a 0805, 10 uF capacitor is between 5.58 uF and 6.32 uF depending on vendor used. Adding worst case of each

value, the value is $10.32 \mu\text{F} + 5.58 \mu\text{F} = 15.9 \mu\text{F}$. Worst case capacitance in this case would be above the minimum value recommended.

For applications with SWxA and SWxB connected together, the minimum bypass capacitor value is $2 \times 14.3 \mu\text{F} = 28.6 \mu\text{F}$. The recommended implementation consists of two 0805, 22 μF capacitors from TDK (C2012X5R0J226MTJ) with a minimum value of 13.61 μF each and one 0603, 2.2 μF capacitor from TDK (C1608X5R0J225K) with minimum value of 1.46 μF . Adding these values: $13.61 \mu\text{F}(x2) + 1.46 \mu\text{F} = 28.68 \mu\text{F}$. Worst case capacitance in this case would be at the minimum value recommended. Based on commercially available parts, another implementation is to use three 0805, 22 μF capacitor. Taking into account the variations (as shown in [Figure 3](#)), the actual capacitance range for each capacitor is between 10.32 μF and 13.61 μF depending on vendor used. Multiplying this by three, the value range is between 30.96 μF and 40.83 μF . Worst case capacitance in this case would be above the minimum value recommended.

Table 3. Buck Switcher Characteristics

Parameter	Condition	Min	Typ	Max	Units
Output Voltage	$2.8 \text{ V} < \text{BP} < 4.65 \text{ V}$ $0 < \text{IL} < 500 \text{ mA}$	0.900 V to 1.675 V in 25 m V steps 1.700 V to 2.200 V in 100 V steps			V
Output Accuracy	PWM Mode, including ripple and load regulation	-50		+50	mV
Transient Load Response	IL from 5 mA to 400 mA in 1 μs IL from 400 mA to 5 mA in 1 μs			+/- 25	mV
Effective Quiescent Current Consumption	PWM MODE		50		μA
	PFM MODE		15		μA
External Components	Inductor	-20%	10	+20%	μH
	Inductor Resistance			0.16	Ω
	Bypass Capacitor	-35%	22	+35%	μF
	Bypass Capacitor ESR	0.005		0.1	Ω

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