dsPIC33AK128MC106 Motor Control Dual In-Line Module (DIM) Information Sheet

Introduction

The dsPIC33AK128MC106 Motor Control DIM (P/N: EV68M17A) is designed to demonstrate the motor control capabilities of the dsPIC33AK128MC106 device. This dsPIC® DSC features a 200 MHz, single-core Digital Signal Controller (DSC) with a 64-bit floating-point unit (FPU) and enhanced on-chip peripherals.

This motor control DIM is designed to take advantage of the high-speed motor control PWM generators, A/D converters, operational amplifiers, comparators and DACs.

The DIM can be used to demonstrate and develop motor control applications by inserting it in the DIM interface header, provided on the compatible motor control development boards. The DIM is designed to run a single motor with all the compatible development boards. Table 1 provides information on the hardware versions of the motor control development boards that are compatible with this DIM. For additional information regarding development boards, refer to the respective user's guide available on the Microchip website (www.microchip.com).

Figure 1. dsPIC33AK128MC106 Motor Control DIM (P/N: EV68M17A)

The LED LD1 (green) indicates the power-on status of the DIM. A general purpose LED LD2 (yellow) is provided on the board for debug purposes. The clock for the dsPIC DSC is generated by the MEMS Oscillator (Y1—DSC6011JI2B-008.0000) provided on the DIM. The 8-pin header J2 is provided for interfacing with the programmer/debugger. Any 8-pin, single-row, 0.100" (2.54 mm) pitch, unshrouded male header can be used (for example, P/N: 61300811121 from Würth Elektronik).

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Table 1. Hardware Compatibility[1]

Development Board	Part Number	Compatible Hardware Revision
MCLV-48V-300W	EV18H47A	All revisions
MCHV-230VAC-1.5kW	EV78U65A	All revisions

Note:

1. The DIM is not compatible with earlier motor control development boards (for example, dsPICDEM™ MCLV-2 Development Board, dsPICDEM MCHV-3 Development Board).

WARNING Do not connect non-isolated oscilloscope probes to the test points on the DIM when inserted in a High-Voltage Development Board. Failure to heed this warning could result in hardware damage.

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1. Pin Mapping

Table 1-1 provides pin mapping from the 64-pin dsPIC33AK128MC106 device to the DIM interface connector.

Table 1-1. Pin Mapping—dsPIC33AK128MC106 to DIM Interface Connector (Sorted By Device Pin Number)

Device Pin No.	dsPIC33AK128MC106 Pin Function	DIM Pin No.	Remarks
1	PGED2/AD2AN6/CMP3C/ISRC2/ IBIAS2/RP1/SDA2/IOMF2/RA0	DIM:035	Connected via RC (R1, C1) filter
		DIM:071	Can be connected via 0R (R35) resistor. When connecting this signal, remove RC (R1, C1) filter
2	AD1AN6/RP8/IOMF1/RA7	DIM:039	Direct connection
3	PGEC2/DACOUT/AD1AN7/AD2AN3/ CMP1D/CMP2D/CMP3D/RP2/SCL2/RA1	—	Test Point TP3 on DIM
4	V_{SS}	DIM:061 to DIM:064, DIM:117 to DIM:120	Digital ground (V_{SS})
5	V_{DD}	DIM:057 to DIM:060, DIM:113 to DIM:116	Digital power (V_{CC})
6	AD1AN10/RP12/RA11	DIM:028	Direct connection
7	AD2AN9/ISRC3/IBIAS3/RP9/RA8	DIM:020	Connected via 0R (R14) resistor
		DIM:026	Can be connected via 0R (R34) resistor
8	AD1ANN3/AD1AN9/RP10/RA9	DIM:024	Direct connection
9	AD2ANN3/AD2AN7/RP11/RA10	DIM:022	Direct connection
10	AV_{SS}	DIM:061 to DIM:064, DIM:117 to DIM:120	Digital ground (V_{SS})
11	AV_{DD}	DIM:057 to DIM:060, DIM:113 to DIM:116	Digital power (V_{CC})
12	OA1OUT/AD1AN0/CMP1A/RP3/RA2	DIM:017	The output of Op Amp1 (OA1) when configured and enabled. Ensure resistor R17 is removed.
		DIM:019	Can be connected via 0R (R17) resistor. When connecting the signal: • Disable amplifier Op Amp1 (OA1) • Remove resistor R6
13	OA1IN-/AD1ANN1/AD2AN0/RP4/RA3	DIM:015	Op Amp1 negative input-connected via amplifier input resistors
14	OA1IN+/AD1AN1/CMP1B/RP5/RA4	DIM:013	Op Amp1 positive input-connected via amplifier input resistors
15	OA3OUT/AD1AN3/CMP3A/RP6/RA5	DIM:033	The output of Op Amp3 (OA3) when configured and enabled. Ensure resistor R9 is removed.
		DIM:035	Can be connected via 0R (R9) resistor. When connecting the signal: • Disable amplifier Op Amp3 (OA3) • Remove resistor R11
16	OA3IN-/AD1AN2/RP7/RA6	DIM:031	Op Amp3 negative input-connected via amplifier input resistors
17	OA3IN+/AD2AN2/CMP3B/RP22/RB5	DIM:029	Op Amp3 positive input-connected via amplifier input resistors

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Table 1-1. Pin Mapping—dsPIC33AK128MC106 to DIM Interface Connector (Sorted By Device Pin Number) (continued)

Device Pin No.	dsPIC33AK128MC106 Pin Function	DIM Pin No.	Remarks
18	V_{SS}	DIM:061 to DIM:064, DIM:117 to DIM:120	Digital ground (V_{SS})
19	V_{DD}	DIM:057 to DIM:060, DIM:113 to DIM:116	Digital power (V_{CC})
20	OA2OUT/AD2AN1/CMP2A/RP17/INT0/RB0	DIM:025	The output of Op Amp2 (OA2) when configured and enabled. Ensure resistor R30 is removed.
		DIM:027	Can be connected via 0R (R30) resistor. When connecting the signal: • Disable amplifier Op Amp2 (OA2) • Remove resistor R25
21	TMS/OA2IN-/AD1AN4/AD2ANN1/ RP18/RB1	DIM:023	Op Amp2 negative input-connected via amplifier input resistors
22	OA2IN+/AD2AN4/CMP2B/RP19/RB2	DIM:021	Op Amp2 positive input-connected via amplifier input resistors
23	AD1AN11/RP25/RB8	DIM:011	Direct connection
24	AD2AN10/RP26/RB9	DIM:009	Direct connection
25	V_{SS}	DIM:061 to DIM:064, DIM:117 to DIM:120	Digital ground (V_{SS})
26	V_{DD}	DIM:057 to DIM:060, DIM:113 to DIM:116	Digital power (V_{CC})
27	PGED1/AD1AN5/CMP1C/ISRC0/IBIAS0/ RP20/SDA1/RB3	DIM:049 (PGD)	Direct connection; also directly connected to Pin 4 of Header J2
28	PGEC1/AD2AN5/CMP2C/ISRC1/IBIAS1/ RP21/SCL1/RB4	DIM:051 (PGC)	Direct connection; also directly connected to Pin 5 of Header J2
29	AD1ANN2/AD1AN8/RP23/RB6	DIM:012	Direct connection
30	AD2ANN2/AD2AN8/RP24/IOMF0/RB7	DIM:010	Direct connection
31	RP27/SCK2/RB10	DIM:041	Connected via 0R (R22) resistor
		DIM:043	Can be connected via 0R (R23) resistor
32	RP28/SDI2/RB11	DIM:040	Direct connection
33	RP41/IOMD11/IOMF11/PCI20/RC8	DIM:046	Direct connection
34	RP42/IOMD10/SDO2/IOMF10/PCI19/RC9	DIM:032	Direct connection
35	RP39/RC6	DIM:042	Direct connection
36	RP40/RC7	DIM:044	Direct connection
37	OSCO/CLKO/RP33/IOMF5/RC0	—	This pin is connected to a general-purpose LED (LD2—Yellow) on the DIM
38	OSCI/CLKI/RP34/IOMF6/RC1	—	CLKI—clock output of MEMS Oscillator (Y1) is connected as an input clock of dsPIC DSC (U1)
39	V_{SS}	DIM:061 to DIM:064, DIM:117 to DIM:120	Digital ground (V_{SS})
40	V_{DD}	DIM:057 to DIM:060, DIM:113 to DIM:116	Digital power (V_{CC})
41	PGEC3/RP35/PWM4H/RC2	DIM:006	Direct connection
42	RP38/PWM4L/RC5	DIM:008	Direct connection
43	PGED3/RP36/PWM3H/IOMD0/RC3	DIM:002	Direct connection
44	RP37/PWM3L/IOMD1/RC4	DIM:004	Direct connection

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Table 1-1. Pin Mapping—dsPIC33AK128MC106 to DIM Interface Connector (Sorted By Device Pin Number) (continued)

Device Pin No.	dsPIC33AK128MC106 Pin Function	DIM Pin No.	Remarks
45	RP43/IOMD9/IOMF9/RC10	DIM:052	Direct connection; also directly connected to Pin 7 of Header J2
46	RP44/IOMD8/IOMF8/RC11	DIM:054	Direct connection; also directly connected to Pin 8 of Header J2
47	V_{SS}	DIM:061 to DIM:064, DIM:117 to DIM:120	Digital ground (V_{SS})
48	V_{DD}	DIM:057 to DIM:060, DIM:113 to DIM:116	Digital power (V_{CC})
49	RP58/IOMF7/RD9	DIM:034	Direct connection
50	RP59/RD10	DIM:036	Direct connection
51	RP49/PWM2H/IOMD2/RD0	DIM:005	Direct connection
52	TCK/RP50/PWM2L/IOMD3/RD1	DIM:007	Direct connection
53	TDO/RP51/PWM1H/IOMD4/RD2	DIM:001	Direct connection
54	TDI/RP52/PWM1L/IOMD5/RD3	DIM:003	Direct connection
55	RP54/ASCL1/RD5	DIM:030	Direct connection
56	RP55/ASDA1/RD6	DIM:112	Direct connection
57	RP56/ASCL2/IOMD7/IOMF4/RD7	DIM:110	Direct connection
58	RP57/ASDA2/IOMD6/IOMF3/RD8	DIM:108	Direct connection
59	V_{SS}	DIM:061 to DIM:064, DIM:117 to DIM:120	Digital ground (V_{SS})
60	V_{DD}	DIM:057 to DIM:060, DIM:113 to DIM:116	Digital power (V_{CC})
61	RP53/PCI22/RD4	DIM:065	Connected via 0R (R32) resistor
		DIM:106	Can be connected via 0R (R33) resistor
62	RP60/RD11	DIM:104	Direct connection
63	RP61/PCI21/RD12	DIM:102	Direct connection
64	$\overline{MCLR}$	DIM:047 ($\overline{MCLR}$)	Direct connection; also directly connected to Pin 1 of Header J2

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Table 1-2 provides pin mapping from the DIM interface connector to the 64-pin dsPIC33AK128MC106 device.

Table 1-2. Pin Mapping—DIM Interface Connector to dsPIC33AK128MC106 (Sorted by DIM Pin Number)

DIM Pin No.	Device Pin No.	dsPIC33AK128MC106 Pin Function	Remarks
DIM:001	53	TDO/RP51/PWM1H/IOMD4/RD2	Direct connection
DIM:002	43	PGED3/RP36/PWM3H/IOMD0/RC3	Direct connection
DIM:003	54	TDI/RP52/PWM1L/IOMD5/RD3	Direct connection
DIM:004	44	RP37/PWM3L/IOMD1/RC4	Direct connection
DIM:005	51	RP49/PWM2H/IOMD2/RD0	Direct connection
DIM:006	41	PGEC3/RP35/PWM4H/RC2	Direct connection
DIM:007	52	TCK/RP50/PWM2L/IOMD3/RD1	Direct connection
DIM:008	42	RP38/PWM4L/RC5	Direct connection
DIM:009	24	AD2AN10/RP26/RB9	Direct connection
DIM:010	30	AD2ANN2/AD2AN8/RP24/IOMF0/RB7	Direct connection
DIM:011	23	AD1AN11/RP25/RB8	Direct connection
DIM:012	29	AD1ANN2/AD1AN8/RP23/RB6	Direct connection
DIM:013	14	OA1IN+/AD1AN1/CMP1B/RP5/RA4	Op Amp1 positive input-connected via amplifier input resistors
DIM:014	—	—	No connection
DIM:015	13	OA1IN-/AD1ANN1/AD2AN0/RP4/RA3	Op Amp1 negative input-connected via amplifier input resistors
DIM:016	—	—	No connection
DIM:017	12	OA1OUT/AD1AN0/CMP1A/RP3/RA2	The output of Op Amp1 (OA1) when configured and enabled. Ensure resistor R17 is removed.
DIM:018	—	—	No connection
DIM:019	12	OA1OUT/AD1AN0/CMP1A/RP3/RA2	Can be connected via 0R (R17) resistor. When connecting the signal: • Disable amplifier Op Amp1 (OA1) • Remove resistor R6
DIM:020	7	AD2AN9/ISRC3/IBIAS3/RP9/RA8	Connected via 0R (R14) resistor
DIM:021	22	OA2IN+/AD2AN4/CMP2B/RP19/RB2	Op Amp2 positive input-connected via amplifier input resistors
DIM:022	9	AD2ANN3/AD2AN7/RP11/RA10	Direct connection
DIM:023	21	TMS/OA2IN-/AD1AN4/AD2ANN1/ RP18/RB1	Op Amp2 negative input-connected via amplifier input resistors
DIM:024	8	AD1ANN3/AD1AN9/RP10/RA9	Direct connection
DIM:025	20	OA2OUT/AD2AN1/CMP2A/RP17/INT0/RB0	The output of Op Amp2 (OA2) when configured and enabled. Ensure resistor R30 is removed.
DIM:026	7	AD2AN9/ISRC3/IBIAS3/RP9/RA8	Can be connected via 0R (R34) resistor
DIM:027	20	OA2OUT/AD2AN1/CMP2A/RP17/INT0/RB0	Can be connected via 0R (R30) resistor. When connecting the signal: • Disable amplifier Op Amp2 (OA2) • Remove resistor R25
DIM:028	6	AD1AN10/RP12/RA11	Direct connection
DIM:029	17	OA3IN+/AD2AN2/CMP3B/RP22/RB5	Op Amp3 positive input-connected via amplifier input resistors

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Table 1-2. Pin Mapping—DIM Interface Connector to dsPIC33AK128MC106 (Sorted by DIM Pin Number) (continued)

DIM Pin No.	Device Pin No.	dsPIC33AK128MC106 Pin Function	Remarks
DIM:030	55	RP54/ASCL1/RD5	Direct connection
DIM:031	16	OA3IN-/AD1AN2/RP7/RA6	Op Amp3 negative input-connected via amplifier input resistors
DIM:032	34	RP42/IOMD10/SDO2/IOMF10/PCI19/RC9	Direct connection
DIM:033	15	OA3OUT/AD1AN3/CMP3A/RP6/RA5	The output of Op Amp3 (OA3) when configured and enabled. Ensure resistor R9 is removed.
DIM:034	49	RP58/IOMF7/RD9	Direct connection
DIM:035	1	PGED2/AD2AN6/CMP3C/ISRC2/ IBIAS2/RP1/SDA2/IOMF2/RA0	Connected via RC (R1, C1) filter
	15	OA3OUT/AD1AN3/CMP3A/RP6/RA5	Can be connected via 0R (R9) resistor. When connecting the signal • Disable amplifier Op Amp3 (OA3) • Remove resistor R11
DIM:036	50	RP59/RD10	Direct connection
DIM:037 (V_{REF})	14, 22, 17	Connected to positive input of amplifiers OA1, OA2 and OA3 through gain resistors	V_{REF} (+1.65V) input from the motor control development board
DIM:038	—	—	No connection
DIM:039	2	AD1AN6/RP8/IOMF1/RA7	Direct connection
DIM:040	32	RP28/SDI2/RB11	Direct connection
DIM:041	31	RP27/SCK2/RB10	Connected via 0R (R22) resistor
DIM:042	35	RP39/RC6	Direct connection
DIM:043	31	RP27/SCK2/RB10	Can be connected via 0R (R23) resistor
DIM:044	36	RP40/RC7	Direct connection
DIM:045	—	—	No connection
DIM:046	33	RP41/IOMD11/IOMF11/PCI20/RC8	Direct connection
DIM:047 ($\overline{MCLR}$)	64	$\overline{MCLR}$	Direct connection; also directly connected to Pin 1 of Header J2
DIM:048	—	—	No connection
DIM:049 (PGD)	27	PGED1/AD1AN5/CMP1C/ISRC0/IBIAS0/ RP20/SDA1/RB3	Direct connection; also directly connected to Pin 4 of Header J2
DIM:050	—	—	No connection
DIM:051 (PGC)	28	PGEC1/AD2AN5/CMP2C/ISRC1/IBIAS1/ RP21/SCL1/RB4	Direct connection; also directly connected to Pin 5 of Header J2
DIM:052	45	RP43/IOMD9/IOMF9/RC10	Direct connection; also directly connected to Pin 7 of Header J2
DIM:053	—	—	No connection
DIM:054	46	RP44/IOMD8/IOMF8/RC11	Direct connection; also directly connected to Pin 8 of Header J2
DIM:055 (VCC_SELECT)	—	—	No connection
DIM:056	—	—	No connection
DIM:057 to DIM:060	5, 11, 19, 26, 40, 48, 60	V_{DD}	Digital power (V_{CC})
DIM:061 to DIM:064	4, 10, 18, 25, 39, 47, 59	V_{SS}	Digital ground (V_{SS})
DIM:065	61	RP53/PCI22/RD4	Connected via 0R (R32) resistor

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Table 1-2. Pin Mapping—DIM Interface Connector to dsPIC33AK128MC106 (Sorted by DIM Pin Number) (continued)

DIM Pin No.	Device Pin No.	dsPIC33AK128MC106 Pin Function	Remarks
DIM:066 to DIM:070	—	—	No connection
DIM:071	1	PGED2/AD2AN6/CMP3C/ISRC2/ IBIAS2/RP1/ SDA2/IOMF2/RA0	Can be connected via 0R (R35) resistor. When connecting this signal, remove RC (R1, C1) filter
DIM:072 to DIM:101	—	—	No connection
DIM:102	63	RP61/PCI21/RD12	Direct connection
DIM:103	—	—	No connection
DIM:104	62	RP60/RD11	Direct connection
DIM:105	—	—	No connection
DIM:106	61	RP53/PCI22/RD4	Can be connected via 0R (R33) resistor
DIM:107	—	—	No connection
DIM:108	58	RP57/ASDA2/IOMD6/IOMF3/RD8	Direct connection
DIM:109	—	—	No connection
DIM:110	57	RP56/ASCL2/IOMD7/IOMF4/RD7	Direct connection
DIM:111	—	—	No connection
DIM:112	56	RP55/ASDA1/RD6	Direct connection
DIM:113 to DIM:116	5, 11, 19, 26, 40, 48, 60	V_{DD}	Digital power (V_{CC})
DIM:117 to DIM:120	4, 10, 18, 25, 39, 47, 59	V_{SS}	Digital ground (V_{SS})

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2. Internal Amplifier

Operational amplifiers internal to the dsPIC33AK128MC106 can be configured and enabled for amplifying motor currents (internal Op Amp configuration). The amplifier circuits are shown in the Figure 2-1 and Figure 4-2. The detailed schematics of the block, “Filter, Feedback and Bias Circuit” used in Figure 2-1, are shown in Figure 2-2.

Figure 2-1. dsPIC® DSC Internal Amplifiers

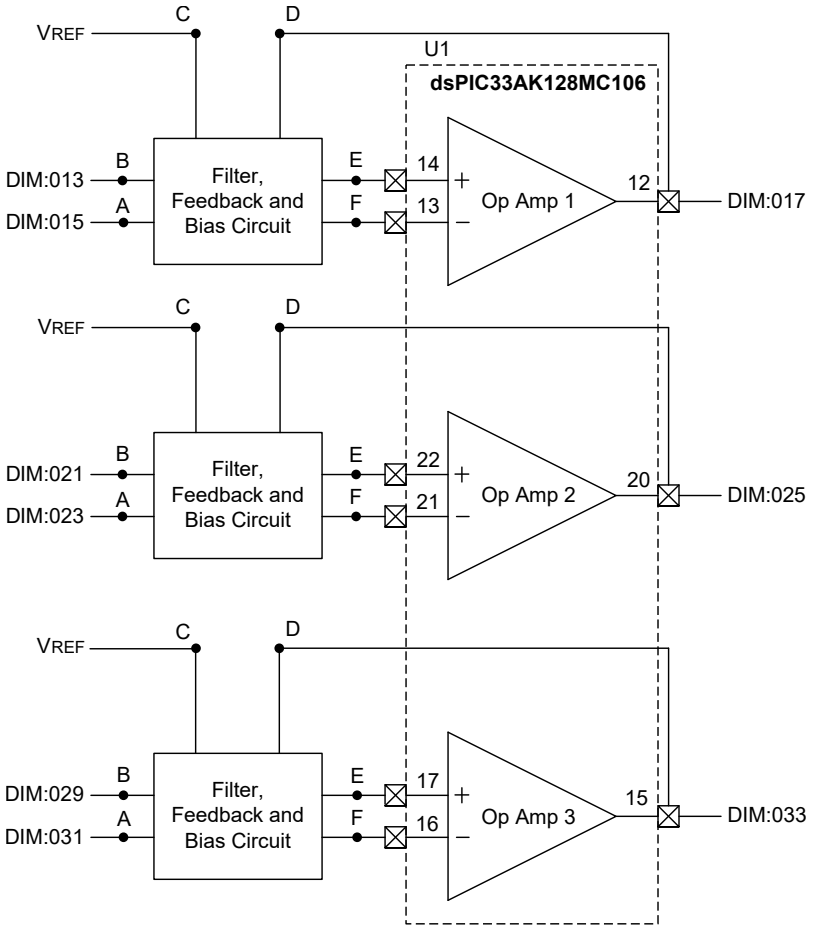

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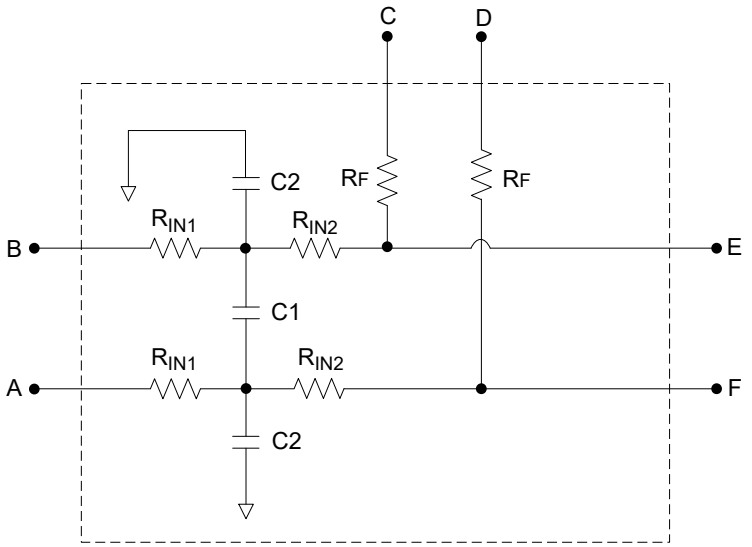
Figure 2-2. Filter, Feedback and Bias Circuit



Equation 2-1 provides the amplifier gain calculations. Equation 2-2 and Equation 2-3 provide the equations to calculate cutoff frequencies of the Differential-mode and Common-mode filters.

Equation 2-1. Amplifier Gain

$$Differential\ Amplifier\ Gain = \frac{Rf}{(R_{IN1} + R_{IN2})}$$

Equation 2-2. Cutoff Frequency Differential-Mode Filter

$$Differential\text{-}mode\ f_{-3\ dB} \cong \frac{1}{2\pi(R_{IN1} + R_{IN2})\left(\frac{C2}{2} + C1\right)}$$

Equation 2-3. Cutoff Frequency Common-Mode Filter

$$Common\text{-}mode\ f_{-3\ dB} \cong \frac{1}{2\pi(R_{IN1})(C2)}$$

Table 2-1 summarizes the amplifier gain and filter cutoff frequencies for the amplifier circuit used in the DIM. The customer can select different values based on the application requirements, ensuring peak current is within the operating range of the motor control development board in which the DIM is inserted.

Table 2-1. Amplifier Gain and Cutoff Frequencies

Component Values					Amplifier Gain	Differential-Mode Filter Cutoff Frequency	Common-Mode Filter Cutoff Frequency
R_{IN1}	R_{IN2}	R_F	C1	C2			
100Ω	100Ω	4.99 kΩ	1000 pF	Not Populated	24.95	796 kHz	—

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3. External Amplifier

Some motor control development boards (see Table 1) are equipped with Operational Amplifiers to amplify the motor phase currents and DC bus current (external Op Amp configuration). Refer to the User's Guide of the specific development board to obtain information on amplifier gain.

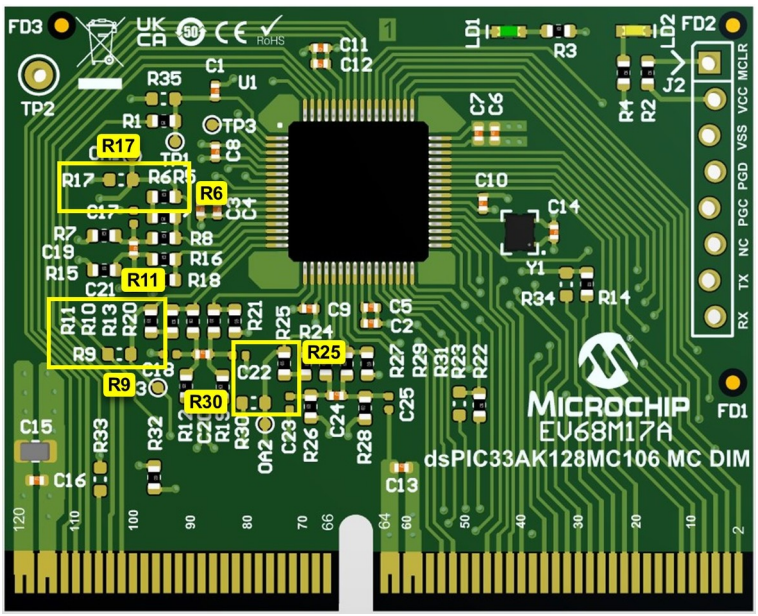
The external amplifier outputs from the development board and the internal amplifier outputs of the dsPIC® DSC are connected to a single analog channel on the DIM.

The DIM is configured to use the internal amplifier outputs of the dsPIC® DSC by default. Table 3-1 summarizes the jumper resistors to be populated and removed to convert the DIM from 'internal Op Amp configuration' to 'external Op Amp configuration' or vice versa.

Table 3-1. Selection Between Internal and External Amplifier Configuration

Operational Amplifier	Jumper Resistor (0R) Settings on the DIM				Firmware Setting
	Internal Amplifier Configuration (default)		External Amplifier Configuration		
	Populate	Remove	Populate	Remove	
OA1	R6	R17	R17	R6	• Configure and enable internal amplifiers in 'internal Op Amp configuration'. • Ensure the internal amplifiers are disabled in the 'external Op Amp configuration'.
OA2	R25	R30	R30	R25	
OA3	R11	R9	R9	R11	

Figure 3-1. Jumper Resistors (0R) on the DIM for Amplifier Output Selection



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4. Board Schematics: Motor Control Dual In-Line Module (MC DIM)

Figure 4-1. Schematic Revision 3.0, Page 1 of 2

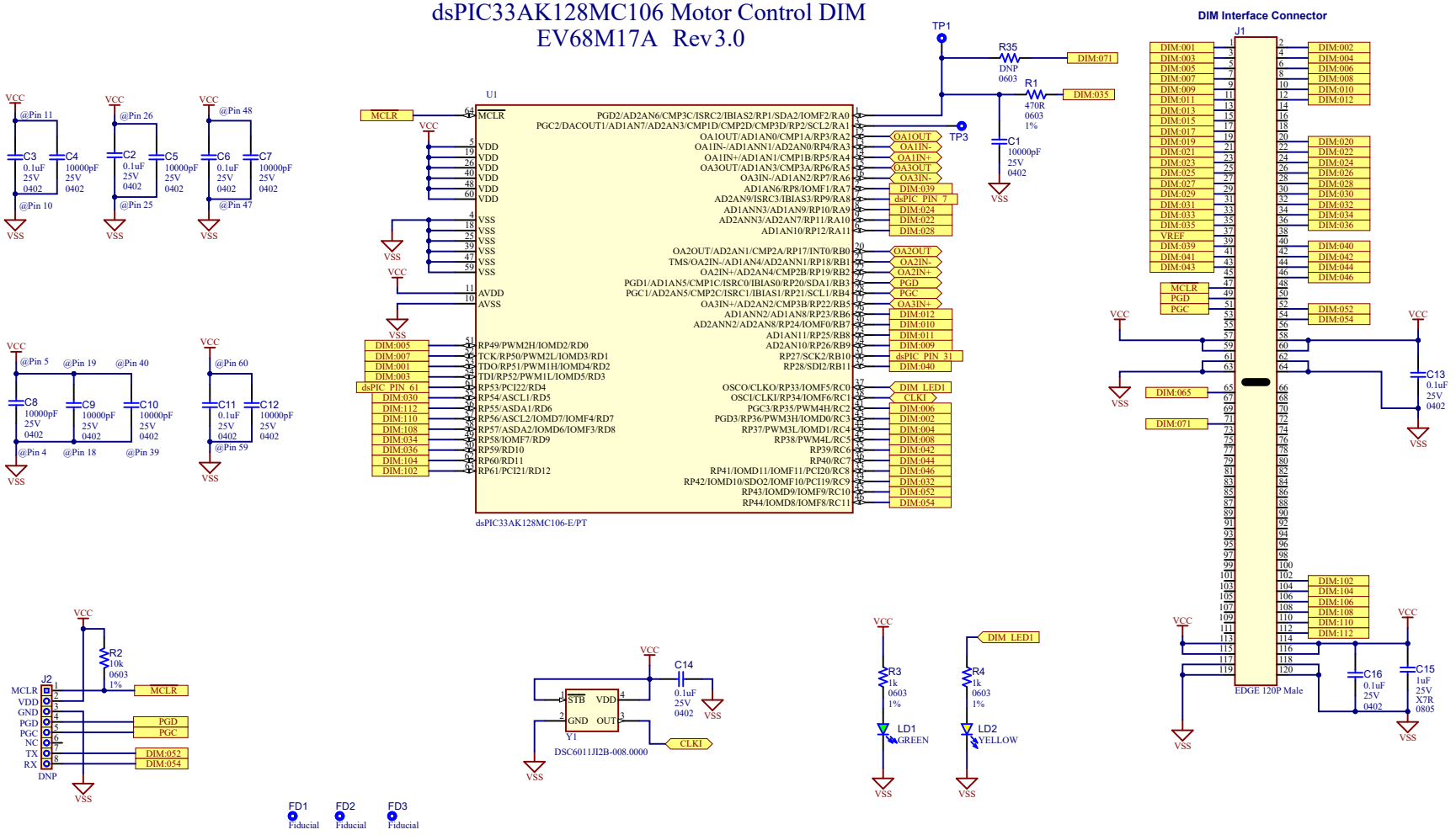

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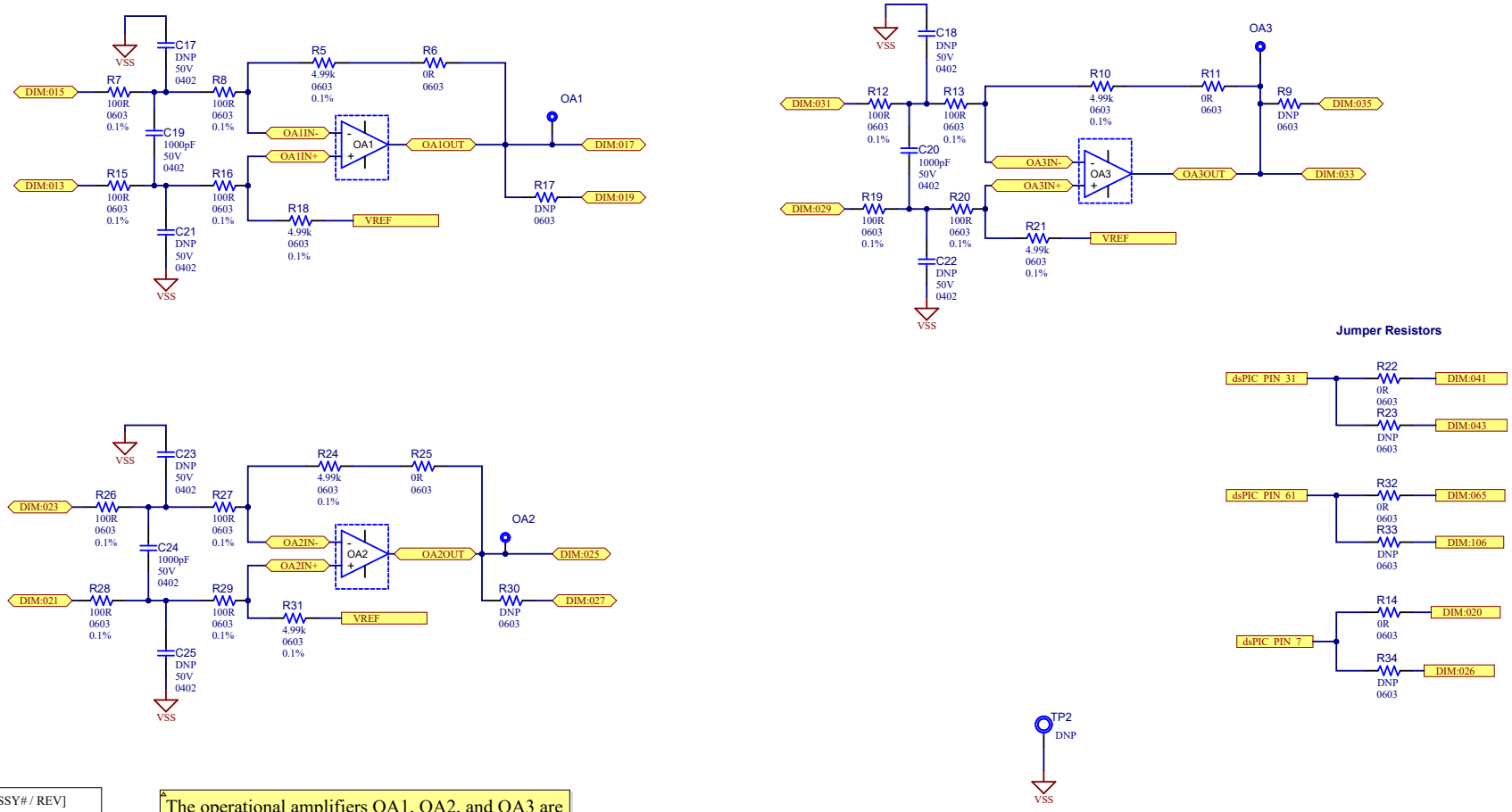
Figure 4-2. Schematic Revision 3.0, Page 2 of 2

dsPIC33AK128MC106 Motor Control DIM
EV68M17A Rev3.0



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