

dsPIC33CK256MC506 Motor Control Plug-In Module (PIM) Information Sheet for Internal Amplifier Configuration

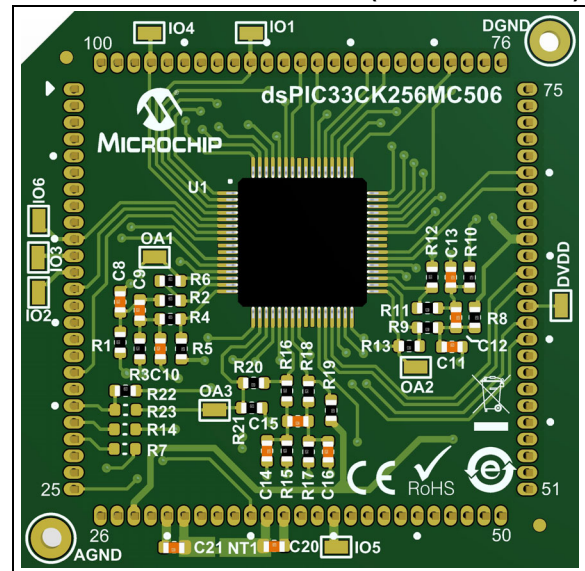
The dsPIC33CK256MC506 Internal Op Amp Motor Control PIM (P/N: EV19G29A) is designed to demonstrate the motor control capabilities of the dsPIC33CK256MC506 device. The dsPIC33CK256MC506 device is a high-performance, 16-bit Digital Signal Controller (DSC).

This Motor Control PIM is designed to take advantage of the high-speed PWM module, a shared ADC core and operational amplifiers in the device to enable various motor control applications.

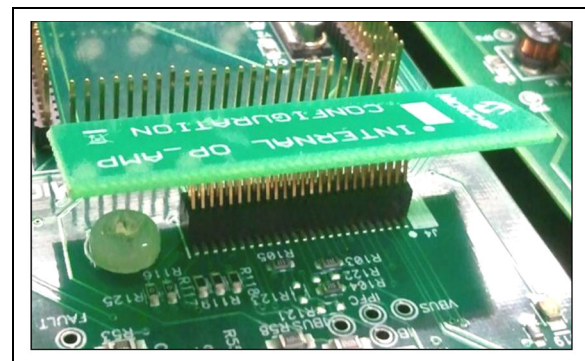
The PIM can be used to demonstrate and develop motor control applications by inserting it in the 100-pin PIM interface header provided on the compatible motor control development boards (see [Table 1](#)). The PIM is designed to run a single motor with all the compatible development boards. When operating this PIM on the dsPICDEM™ MCLV-2 Development Board, insert an internal op amp configuration matrix board (see [Figure 2](#)) on the J14 header provided on the board. In the case of dsPICDEM MCHV-2/MCHV-3 Development Boards, insert an internal op amp configuration matrix board onto the J4 header (as shown in [Figure 2](#)) on the board. This PIM can be used on the dsPICDEM MCHV-3 Development Board to implement and demonstrate single-stage boost Power Factor Correction (PFC) control, along with Field-Oriented Control (FOC). For additional information regarding development boards, refer to the respective user's guide available on the Microchip website (www.microchip.com). [Table 1](#) provides information on the hardware versions of the motor control boards that are compatible with this PIM.

Refer to the specific motor control board user's guide for the hardware version identification information.

**FIGURE 1: dsPIC33CK256MC506
INTERNAL OP AMP MOTOR
CONTROL PIM (P/N: EV19G29A)**



**FIGURE 2: INTERNAL OP AMP
CONFIGURATION BOARD**



dsPIC33CK256MC506

TABLE 1: HARDWARE COMPATIBILITY

Compatible Development Board	Part Number	Compatible Hardware Revision
dsPICDEM™ MCHV Development Board	DM330023	Not Compatible
dsPICDEM MCHV-2 Development Board	DM330023-2	All Revisions
dsPICDEM MCHV-3 Development Board	DM330023-3	All Revisions
dsPICDEM MCLV Development Board	DM330021	Not Compatible
dsPICDEM MCLV-2 Development Board	DM330021-2	All Revisions
Low-Voltage Motor Control Development Bundle	DV330100	Not Compatible
dsPICDEM MCSM Development Board	DM330022/DM330022-1	All Revisions

WARNING

Do not connect non-isolated oscilloscope probes to the test points on the PIM when inserted and in use with the dsPICDEM™ MCHV-2 or MCHV-3 Development Board. Failure to heed this warning could result in hardware damage.

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Table 2 provides the mapping between the 64-pin dsPIC33CK256MC506 device and the 100-pin PIM.

TABLE 2: DEVICE TO PIM MAPPING (ORDERED BY DEVICE PIN NUMBER)

Device Pin #	PIM Pin #	dsPIC33CK256MC506 Device Functional Description	Remarks
1	PIM:94	RP46/PWM1H/RB14	Direct Connection.
2	PIM:93	RP47/PWM1L/RB15	Direct Connection.
3	PIM:82	RP60/RC12	Direct Connection.
4	PIM:91	RP61/RC13	Direct Connection. Test point IO1 is provided on the pin.
5	PIM:97	RP62/RC14	Direct Connection. Test point IO4 is provided on the pin.
6	PIM:10	RP63/RC15	Direct Connection. Test point IO6 is provided on the pin.
7	PIM:13	$\overline{\text{MCLR}}$	Direct Connection.
8	PIM:18	RP79/PCI22/RD15	Direct Connection.
9	PIM:15, 36, 45, 65, 75 ⁽²⁾	Vss	Digital Ground (DGND).
10	PIM:02, 16, 37, 46, 62, 86 ⁽¹⁾	VDD	Digital Power (DVDD).
11	PIM:11	RP78/PCI21/RD14	Direct Connection. Test point IO3 is provided on the pin.
12	PIM:12	ANN0/RP77/RD13	Direct Connection. Test point IO2 is provided on the pin.
13	PIM:35	AN12/RP48/RC0	Direct Connection.
14	—	OA1OUT/AN0/CMP1A/IBIAS0/RA0	The output of Op Amp 1 (OA1) when configured and enabled.
	PIM:22 ⁽⁴⁾		Can be connected via a 0 Ohm resistor (R7). Used in external amplifier configuration.
15	PIM:66	OA1IN-/AN16/RA1	Op Amp 1 Negative Input.
16	PIM:74	OA1IN+/AN9/RA2	Op Amp 1 Positive Input.
17	PIM:25	DACOUT1/AN3/CMP1C/RA3	Direct Connection.
18	—	OA3OUT/AN4/IBIAS3/RA4	The output of Op Amp 3 (OA3) when configured and enabled.
	PIM:20 ⁽⁴⁾		Can be connected via a 0 Ohm resistor (R23). Used in external amplifier configuration.
19	PIM:30	AVDD	Analog Power (AVDD).
20	PIM:31	AVss	Analog Ground (AVss).
21	PIM:40	RP76/RD12	Direct Connection. Test point IO5 is provided on the pin.
22	PIM:67	OA3IN-/AN13/CMP1B/ISRC0/RP49/RC1	Op Amp 3 Negative Input.
23	PIM:66	OA3IN+/AN14/CMP2B/ISRC1/RP50/RC2	Op Amp 3 Positive Input.
24	PIM:60	AN19/IBIAS1/RP54/RC6	Direct Connection.
25	PIM:02, 16, 37, 46, 62, 86 ⁽¹⁾	VDD	Digital Power (DVDD).
26	PIM:15, 36, 45, 65, 75 ⁽²⁾	Vss	Digital Ground (DGND).
27	PIM:32	AN15/CMP2A/IBIAS2/RP51/RC3	Direct Connection.
28	PIM:63	OSCI/CLKI/AN5/RP32/RB0	Direct Connection (OSCI).
29	PIM:64	OSCO/CLKO/AN6/RP33/RB1	Direct Connection (OSCO).

Note 1: Digital Power (DVDD) pins are shorted together on the PIM.

Note 2: Digital Ground (DGND) pins are shorted together on the PIM.

Note 3: The signal connects to the device pin via a jumper resistor(0 Ohm). When needed, remove the jumper resistor to disconnect the signal.

Note 4: The PIM pin can be connected to the device pin through a jumper resistor. This is populated in the external amplifier configuration, where the amplifier is disabled and the amplifier feedback resistors are removed.

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TABLE 2: DEVICE TO PIM MAPPING (ORDERED BY DEVICE PIN NUMBER) (CONTINUED)

Device Pin #	PIM Pin #	dsPIC33CK256MC506 Device Functional Description	Remarks
30	—	CMP2C/RP75/RD11	The output of Op Amp 3 (OA3OUT) connects to an input of Comparator 2 (CMP2C) via a 0 Ohm resistor (R21) to generate an overcurrent trip, if needed.
31	PIM:61	AN18/ISRC3/RP74/RD10	Direct Connection.
32 ⁽³⁾	PIM:20	AN7/ISRC2/RP55/RC7	Connected via a 0 Ohm resistor (R22). An alternate analog channel to sample the signal on PIM:20.
33	—	OA2OUT/AN1/CMP1D/CMP2D/RP34/INT0/RB2	The output of Op Amp 2 (OA2) when configured and enabled.
	PIM:21 ⁽⁴⁾		Can be connected via a 0 Ohm resistor (R14). Used in external amplifier configuration
34	PIM:66	PGD2/OA2IN-/AN8/RP35/RB3	Op Amp 2 Negative Input.
35	PIM:73	PGC2/OA2IN+/AN17/RP36/RB4	Op Amp 2 Positive Input.
36	PIM:49	RP56/ASDA1/SCK2/RC8	Direct Connection.
37	PIM:50	RP57/ASCL1/SDI2/RC9	Direct Connection.
38	PIM:69	RP73/PCI20/RD9	Direct Connection.
39	PIM:70	RP72/SDO2/PCI19/RD8	Direct Connection.
40	PIM:15, 36, 45, 65, 75 ⁽²⁾	Vss	Digital Ground (DGND).
41	PIM:02, 16, 37, 46, 62, 86 ⁽¹⁾	VDD	Digital Power (DVDD).
42	PIM:48	RP71/RD7	Direct Connection.
43	PIM:47	RP70/RD6	Direct Connection.
44	PIM:80	RP69/RD5	Direct Connection.
45	PIM:27	PGD3/RP37/RB5	Direct Connection (PGD).
46	PIM:26	PGC3/RP38/RB6	Direct Connection (PGC).
47	PIM:24	TDO/AN2/RP39/RB7	Direct Connection.
48	PIM:23	PGD1/AN10/RP40/SCL1/RB8	Direct Connection.
49	PIM:79	PGC1/AN11/RP41/SDA1/RB9	Direct Connection.
50	PIM:68	RP52/RC4	Direct Connection.
51	PIM:76	RP53/RC5	Direct Connection.
52	PIM:83	RP58/RC10	Direct Connection.
53	PIM:84	RP59/RC116	Direct Connection.
54	PIM:01	RP68/RD4	Direct Connection.
55	PIM:87	RP67/RD3	Direct Connection.
56	PIM:15, 36, 45, 65, 75 ⁽²⁾	Vss	Digital Ground (DGND).
57	PIM:02, 16, 37, 46, 62, 86 ⁽¹⁾	VDD	Digital Power (DVDD).
58	PIM:88	RP66/RD2	Direct Connection.
59	PIM:78	RP65/PWM4H/RD1	Direct Connection.
60	PIM:19	RP64/PWM4L/RD0	Direct Connection.
61	PIM:03	TMS/RP42/PWM3H/RB10	Direct Connection.
62	PIM:100	TCK/RP43/PWM3L/RB11	Direct Connection.
63	PIM:99	TDI/RP44/PWM2H/RB12	Direct Connection.
64	PIM:98	RP45/PWM2L/RB13	Direct Connection.

Note 1: Digital Power (DVDD) pins are shorted together on the PIM.

2: Digital Ground (DGND) pins are shorted together on the PIM.

3: The signal connects to the device pin via a jumper resistor(0 Ohm). When needed, remove the jumper resistor to disconnect the signal.

4: The PIM pin can be connected to the device pin through a jumper resistor. This is populated in the external amplifier configuration, where the amplifier is disabled and the amplifier feedback resistors are removed.

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Table 3 provides the mapping between the 100-pin PIM and the 64-pin dsPIC33CK256MC506 device.

TABLE 3: PIM TO DEVICE MAPPING (ORDERED BY PIM PIN NUMBER)

PIM Pin #	Device Pin #	dsPIC33CK256MC506 Pin Functional Description	Remarks
PIM:01	54	RP68/RD4	Direct Connection.
PIM:02 ⁽¹⁾	10, 25, 41, 57	VDD	Digital Power (DVDD).
PIM:03	61	TMS/RP42/PWM3H/RB10	Direct Connection.
PIM:04	—	—	Not Connected.
PIM:05	—	—	Not Connected.
PIM:06	—	—	Not Connected.
PIM:07	—	—	Not Connected.
PIM:08	—	—	Not Connected.
PIM:09	—	—	Not Connected.
PIM:10	6	RP63/RC15	Direct Connection. Test point IO6 is provided on the pin.
PIM:11	11	RP78/PCI21/RD14	Direct Connection. Test point IO3 is provided on the pin.
PIM:12	12	ANN0/RP77/RD13	Direct Connection. Test point IO2 is provided on the pin.
PIM:13	7	MCLR	Direct Connection.
PIM:14	—	—	Not Connected.
PIM:15 ⁽²⁾	9, 26, 40, 56	VSS	Digital Ground (DGND).
PIM:16 ⁽¹⁾	10, 25, 41, 57	VDD	Digital Power (DVDD).
PIM:17	—	—	Not Connected.
PIM:18	8	RP79/PCI22/RD15	Direct Connection.
PIM:19	60	RP64/PWM4L/RD0	Direct Connection.
PIM:20	32 ⁽³⁾	AN7/ISRC2/RP55/RC7	Connected via a 0 Ohm resistor (R22). An alternate analog channel to sample the signal on PIM:20.
	18 ⁽⁴⁾	OA3OUT/AN4/IBIAS3/RA4	Can be connected via a 0 Ohm resistor (R23). Used in external amplifier configuration.
PIM:21	33 ⁽⁴⁾	OA2OUT/AN1/CMP1D/CMP2D/RP34/INT0/RB2	Can be connected via a 0 Ohm resistor (R14). Used in external amplifier configuration.
PIM:22	14 ⁽⁴⁾	OA1OUT/AN0/CMP1A/IBIAS0/RA0	Can be connected via a 0 Ohm resistor (R7). Used in external amplifier configuration.
PIM:23	48	PGD1/AN10/RP40/SCL1/RB8	Direct Connection.
PIM:24	47	TDO/AN2/RP39/RB7	Direct Connection.
PIM:25	17	DACOUT1/AN3/CMP1C/RA3	Direct Connection.
PIM:26	46	PGC3/RP38/RB6	Direct Connection (PGC).
PIM:27	45	PGD3/RP37/RB5	Direct Connection (PGD).
PIM:28	—	VREF	External 1.65V reference.
PIM:29	—	—	Not Connected.

Note 1: Digital Power (DVDD) pins are shorted together on the PIM.

Note 2: Digital Ground (DGND) pins are shorted together on the PIM.

Note 3: The signal connects to the device pin via a jumper resistor (0 Ohm). When needed, remove the jumper resistor to disconnect the signal.

Note 4: The PIM pin can be connected to the device pin through a jumper resistor. This is populated in the external amplifier configuration, where the amplifier is disabled and the amplifier feedback resistors are removed.

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TABLE 3: PIM TO DEVICE MAPPING (ORDERED BY PIM PIN NUMBER) (CONTINUED)

PIM Pin #	Device Pin #	dsPIC33CK256MC506 Pin Functional Description	Remarks
PIM:30	19	AVDD	Analog Power (AVDD).
PIM:31	20	AVSS	Analog ground (AVSS).
PIM:32	27	AN15/CMP2A/IBIAS2/RP51/RC3	Direct Connection.
PIM:33	—	—	Not Connected.
PIM:34	—	—	Not Connected.
PIM:35	13	AN12/RP48/RC0	Direct Connection.
PIM:36 ⁽²⁾	9, 26, 40, 56	Vss	Digital Ground (DGND).
PIM:37 ⁽¹⁾	10, 25, 41, 57	VDD	Digital Power (DVDD).
PIM:38	—	—	Not Connected.
PIM:39	—	—	Not Connected.
PIM:40	21	RP76/RD12	Direct Connection. Test point IO5 is provided on the pin.
PIM:41	—	—	Not Connected.
PIM:42	—	—	Not Connected.
PIM:43	—	—	Not Connected.
PIM:44	—	—	Not Connected.
PIM:45 ⁽²⁾	9, 26, 40, 56	Vss	Digital Ground (DGND).
PIM:46 ⁽¹⁾	10, 25, 41, 57	VDD	Digital Power (DVDD).
PIM:47	43	RP70/RD6	Direct Connection.
PIM:48	42	RP71/RD7	Direct Connection.
PIM:49	36	RP56/ASDA1/SCK2/RC8	Direct Connection.
PIM:50	37	RP57/ASCL1/SDI2/RC9	Direct Connection.
PIM:51	—	—	Not Connected.
PIM:52	—	—	Not Connected.
PIM:53	—	—	Not Connected.
PIM:54	—	—	Not Connected.
PIM:55	—	—	Not Connected.
PIM:56	—	—	Not Connected.
PIM:57	—	—	Not Connected.
PIM:58	—	—	Not Connected.
PIM:59	—	—	Not Connected.
PIM:60	24	AN19/IBIAS1/RP54/RC6	Direct Connection.
PIM:61	31	AN18/ISRC3/RP74/RD10	Direct Connection.
PIM:62 ⁽¹⁾	10, 25, 41, 57	VDD	Digital Power (DVDD).
PIM:63	28	OSCI/CLKI/AN5/RP32/RB0	Direct Connection (OSCI).
PIM:64	29	OSCO/CLKO/AN6/RP33/RB1	Direct Connection (OSCO).
PIM:65 ⁽²⁾	9, 26, 40, 56	Vss	Digital Ground (DGND).

- Note 1:** Digital Power (DVDD) pins are shorted together on the PIM.
Note 2: Digital Ground (DGND) pins are shorted together on the PIM.
Note 3: The signal connects to the device pin via a jumper resistor (0 Ohm). When needed, remove the jumper resistor to disconnect the signal.
Note 4: The PIM pin can be connected to the device pin through a jumper resistor. This is populated in the external amplifier configuration, where the amplifier is disabled and the amplifier feedback resistors are removed.

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TABLE 3: PIM TO DEVICE MAPPING (ORDERED BY PIM PIN NUMBER) (CONTINUED)

PIM Pin #	Device Pin #	dsPIC33CK256MC506 Pin Functional Description	Remarks
PIM:66	15	OA1IN-/AN16/RA1	Op Amp 1 Negative Input.
	23	OA3IN+/AN14/CMP2B/ISRC1/RP50/RC2	Op Amp 3 Positive Input.
	34	PGD2/OA2IN-/AN8/RP35/RB3	Op Amp 2 Negative Input.
PIM:67	22	OA3IN-/AN13/CMP1B/ISRC0/RP49/RC1	Op Amp 3 Negative Input.
PIM:68	50	RP52/RC4	Direct Connection.
PIM:69	38	RP73/PCI20/RD9	Direct Connection.
PIM:70	39	RP72/SDO2/PCI19/RD8	Direct Connection.
PIM:71	—	—	Not Connected.
PIM:72	—	—	Not Connected.
PIM:73	35	PGC2/OA2IN+/AN17/RP36/RB4	Op Amp 2 Positive Input.
PIM:74	16	OA1IN+/AN9/RA2	Op Amp 1 Positive Input.
PIM:75 ⁽²⁾	9, 26, 40, 56	Vss	Digital Ground (DGND).
PIM:76	51	RP53/RC5	Direct Connection.
PIM:77	—	—	Not Connected.
PIM:78	59	RP65/PWM4H/RD1	Direct Connection.
PIM:79	49	PGC1/AN11/RP41/SDA1/RB9	Direct Connection.
PIM:80	44	RP69/RD5	Direct Connection.
PIM:81	—	—	Not Connected.
PIM:82	3	RP60/RC12	Direct Connection.
PIM:83	52	RP58/RC10	Direct Connection.
PIM:84	53	RP59/RC11	Direct Connection.
PIM:85	—	—	Not Connected.
PIM:86 ⁽¹⁾	10, 25, 41, 57	VDD	Digital Power (DVDD).
PIM:87	55	RP67/RD3	Direct Connection.
PIM:88	58	RP66/RD2	Direct Connection.
PIM:89	—	—	Not Connected.
PIM:90	—	—	Not Connected.
PIM:91	4	RP61/RC13	Direct Connection. Test point IO1 is provided on the pin.
PIM:92	—	—	Not Connected.
PIM:93	2	RP47/PWM1L/RB15	Direct Connection.
PIM:94	1	RP46/PWM1H/RB14	Direct Connection.
PIM:95	—	—	Not Connected.
PIM:96	—	—	Not Connected.
PIM:97	5	RP62/RC14	Direct Connection. Test point IO4 is provided on the pin.
PIM:98	64	RP45/PWM2L/RB13	Direct Connection.
PIM:99	63	TDI/RP44/PWM2H/RB12	Direct Connection.
PIM:100	62	TCK/RP43/PWM3L/RB11	Direct Connection.

Note 1: Digital Power (DVDD) pins are shorted together on the PIM.

Note 2: Digital Ground (DGND) pins are shorted together on the PIM.

Note 3: The signal connects to the device pin via a jumper resistor (0 Ohm). When needed, remove the jumper resistor to disconnect the signal.

Note 4: The PIM pin can be connected to the device pin through a jumper resistor. This is populated in the external amplifier configuration, where the amplifier is disabled and the amplifier feedback resistors are removed.

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INTERNAL AMPLIFIER

Operational amplifiers internal to the dsPIC33CK256MC506 can be configured and enabled for amplifying motor currents. The amplifier circuits are shown in Figure 3. The detailed schematics of the block, “Filter, Feedback and Bias Circuit” used in Figure 3, are shown in Figure 4.

FIGURE 3: dsPIC® DSC INTERNAL AMPLIFIERS

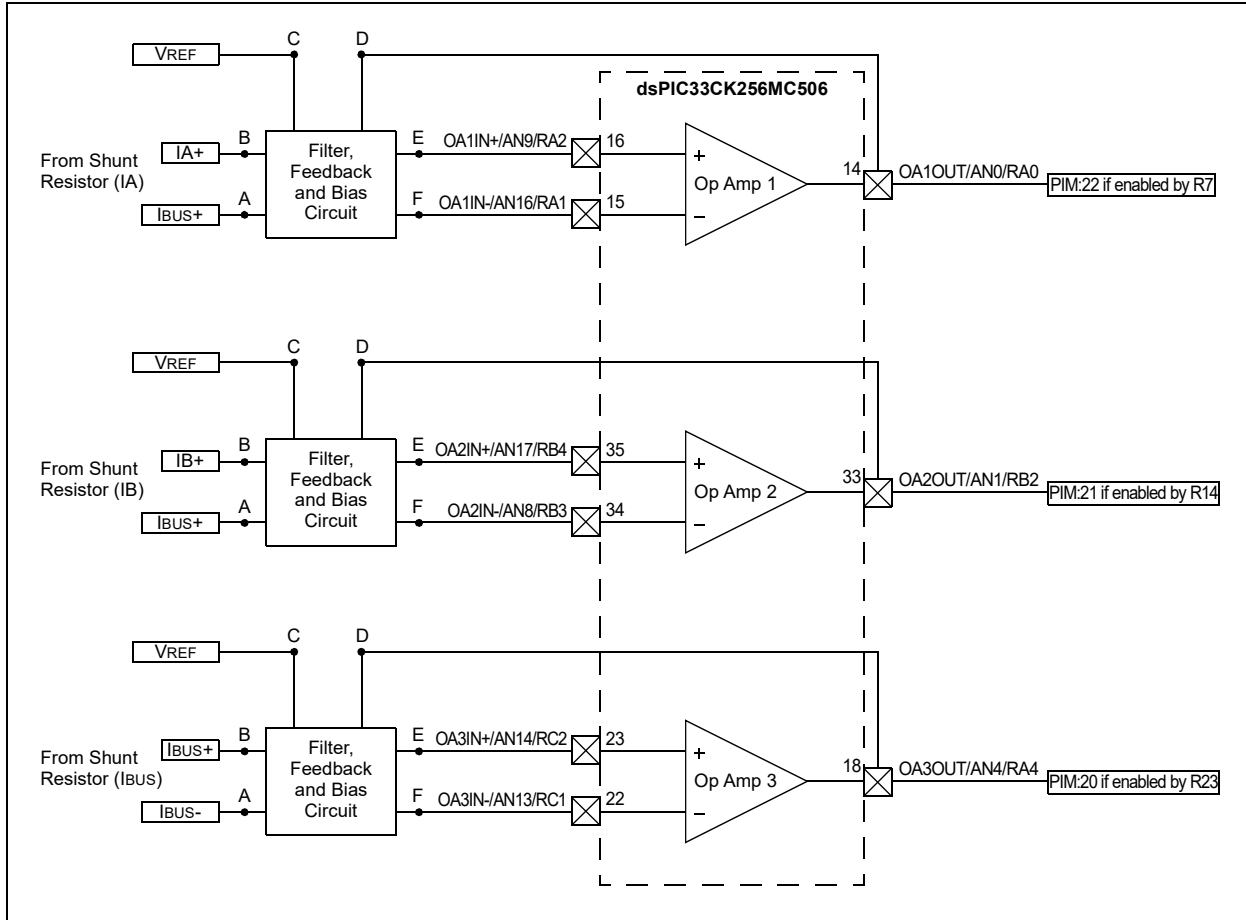
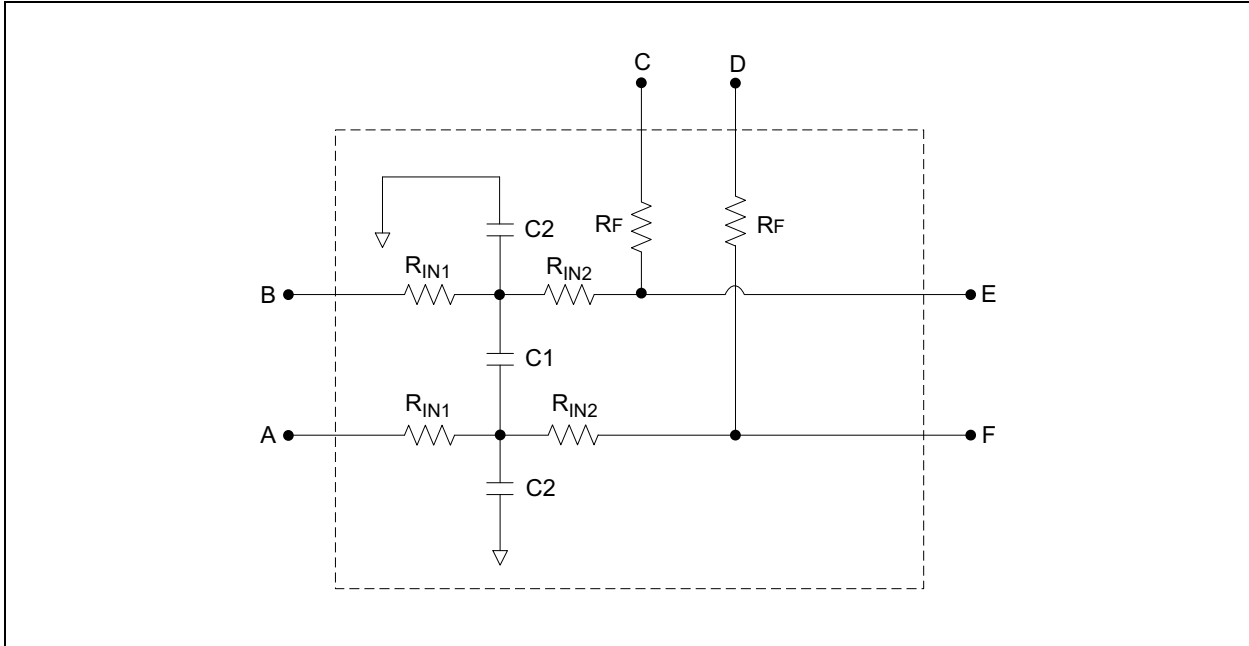


FIGURE 4: FILTER, FEEDBACK AND BIAS CIRCUIT



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

EQUATION 1: AMPLIFIER GAIN

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

EQUATION 2: CUTOFF FREQUENCY DIFFERENTIAL-MODE FILTER

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

EQUATION 3: CUTOFF FREQUENCY COMMON-MODE FILTER

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

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Table 4 summarizes the amplifier gain and filter cutoff frequencies of the amplifiers on the PIM. Customers can select different values for configuring the internal amplifier gain and filter cutoff frequencies based on the application requirements. However, make sure the peak current of the motor control board is within its operating range.

The output of amplifier OA3 is connected to one of the inputs (CMP2C) of the internal comparator CMP2 through jumper resistor R21. If the amplifier OA3 is used for bus current amplification, the CMP2 can be configured and used for overcurrent trip.

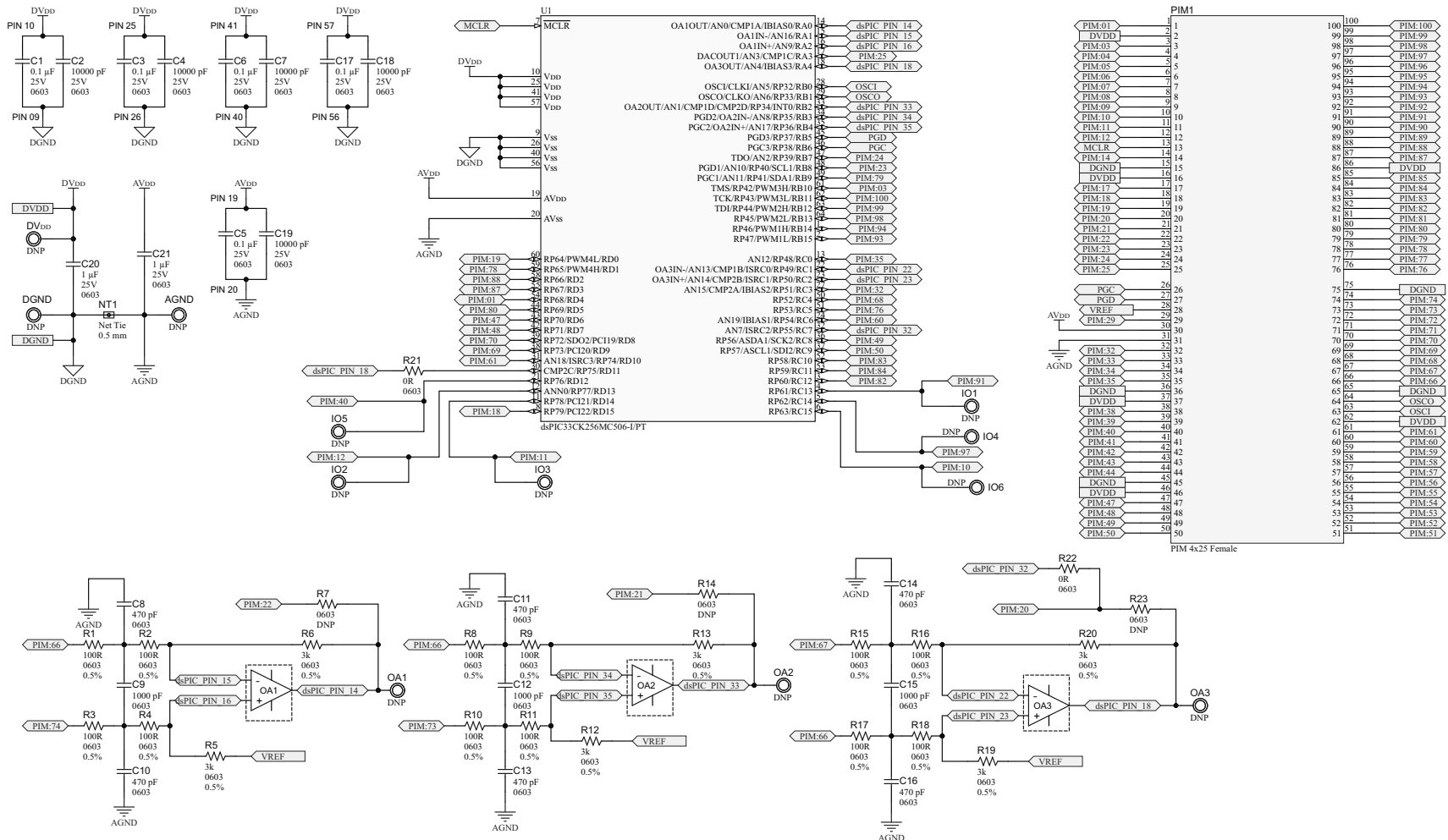
TABLE 4: AMPLIFIER GAIN AND CUTOFF FREQUENCIES

Component Values					Amplifier Gain	Differential-Mode Filter Cutoff Frequency	Common-Mode Filter Cutoff Frequency
R _{IN1}	R _{IN2}	R _F	C1	C2			
100Ω	100Ω	3 kΩ	1000 pF	470 pF	15	644 kHz	3.3 MHz

dsPIC33CK256MC506 Motor Control Plug-In Module (PIM) for Internal Op Amp Configuration

Schematic Revision 1.0

dsPIC33CK256MC506 Internal Op Amp Motor Control PIM



The operational amplifiers OA1, OA2 and OA3 are internal to dsPIC33CK256MC506

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NOTES:

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