

## dsPIC33CK64MC105 Motor Control Plug-In Module (PIM) Information Sheet for Internal Op Amp Configuration

The dsPIC33CK64MC105 Internal Op Amp Motor Control PIM (P/N: MA330051-2) is designed to demonstrate the motor control capabilities of the dsPIC33CK64MC105 device using internal op amps available in the device.

The dsPIC33CK64MC105 device is a high-performance, 16-bit Digital Signal Controller (DSC). This Motor Control PIM is designed to take advantage of the high-resolution 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](http://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: dsPIC33CK64MC105 INTERNAL OP AMP MOTOR CONTROL PIM (MA330051-2)**



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



# dsPIC33CK64MC105

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**TABLE 1: HARDWARE COMPATIBILITY**

<b>Development Board</b>	<b>Part Number</b>	<b>Compatible Hardware Version(s)</b>
dsPICDEM™ MCHV Development Board	DM330023	Not Compatible
dsPICDEM MCLV Development Board	DM330021	Not Compatible
Low-Voltage Motor Control Development Bundle	DV330100	Not Compatible
dsPICDEM MCLV-2 Development Board	DM330021-2	All Revisions
dsPICDEM MCHV-2 Development Board	DM330023-2	All Revisions
dsPICDEM MCHV-3 Development Board	DM330023-3	All Revisions

## **WARNING**

**Do not connect non-isolated oscilloscope probes to the test points on the PIM while 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 mapping between the 48-pin device pinout and the 100-pin PIM.

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

Device Pin #	PIM Pin #	dsPIC33CK64MC105 Device Functional Description	Remarks
1	PIM:94	RP46/PWM1H/RB14	Direct Connection
2	PIM:93	RP47/PWM1L/RB15	Direct Connection
3	PIM:60	RP60/RC12	Direct Connection
4	PIM:01	RP61/RC13	Direct Connection
5	PIM:13	$\overline{\text{MCLR}}$	Direct Connection
6	PIM:47	ANN0/RP77/RD13	Direct Connection
7	PIM:35	AN12/RP48/RC0	Direct Connection
8	—	OA1OUT/AN0/CMP1A/IBIAS0/RA0	Op Amp Output
9	PIM:66	OA1IN-/RA1	Op Amp Input
10	PIM:74	OA1IN+/AN9/RA2	Op Amp Input
11	PIM:25	DACOUT/AN3/CMP1C/RA3	Direct Connection
12	—	OA3OUT/AN4/IBIAS3/RA4	Op Amp Output
13	PIM:30	AVDD	Analog Power (AVDD)
14	PIM:31 <sup>(5)</sup>	AVSS	Analog Ground (AGND)
15	PIM:67	OA3IN-/AN13/CMP1B/ISRC0/RP49/RC1	Op Amp Input
16	PIM:66	OA3IN+/AN14/ISRC1/RP50/RC2	Op Amp Input
17	PIM:19	IBIAS1/RP54/RC6	Direct Connection
18	PIM:02, 16, 37, 46, 62, 86 <sup>(3)</sup>	VDD	Digital Power (DVDD)
19	PIM:15, 36, 45, 65, 75 <sup>(4)</sup>	VSS	Digital Ground (DGND)
20	PIM:32	AN15/IBIAS2/RP51/RC3	Direct Connection
21	PIM:63	OSCI/CLKI/AN5/RP32/RB0	Direct Connection
22	PIM:64	OSCO/CLKO/AN6/RP33/RB1	Direct Connection
23	PIM:48	ISRC3/RP74/RD10	Direct Connection
24	PIM:70	ISRC2/RP55/RC7	Direct Connection
25	—	OA2OUT/AN1/AN7/CMP1D/RP34/INT0/RB2	Op Amp Output
26	PIM:66	PGD2/OA2IN-/AN8/RP35/RB3	Op Amp Input
27	PIM:73	PGC2/OA2IN+/RP36/RB4	Op Amp Input
28	PIM:49	RP56/ASDA1/SCK2/RC8	Direct Connection
29	PIM:68	RP57/ASCL1/SDI2/RC9	Direct Connection
30	PIM:18	RP72/SDO2/PCI19/RD8	Direct Connection
31	PIM:15, 36, 45, 65, 75 <sup>(4)</sup>	VSS	Digital Ground (DGND)
32	PIM:02, 16, 37, 46, 62, 86 <sup>(3)</sup>	VDD	Digital Power (DVDD)
33	PIM:27	PGD3/RP37/RB5	Direct Connection
34	PIM:26	PGC3/RP38/RB6	Direct Connection
35	PIM:24	TDO/AN2/RP39/RB7	Direct Connection
36	PIM:23	PGD1/AN10/RP40/SCL1/RB8	Direct Connection

- Note 1:** The PIM pin is directly connected to the device pin through a 0 Ohm resistor (default), which can be removed if desired.
- Note 2:** The PIM pin can be connected to a device pin through a 0 Ohm resistor, if required. For proper operation, ensure that other 0 Ohm resistors connected to the same device pin are removed.
- Note 3:** Digital Power (DVDD) pins are shorted together on the PIM.
- Note 4:** Digital Ground (DGND) pins are shorted together on the PIM.
- Note 5:** Analog Ground (AGND) connection via PIM:31 is shorted with Digital Ground (DGND) through 0 Ohm resistor, R22, on the PIM.

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

Device Pin #	PIM Pin #	dsPIC33CK64MC105 Device Functional Description	Remarks
37	PIM:79	PGC1/AN11/RP41/SDA1/RB9	Direct Connection
38	PIM:84	RP52/RC4	Direct Connection
39	PIM:80	RP53/RC5	Direct Connection
40	PIM:61 <sup>(2)</sup>	RP58/RC10	Can be connected via 0 Ohm Resistor
	PIM:78 <sup>(1)</sup>		Connected via 0 Ohm Resistor
41	PIM:83	RP59/RC11	Direct Connection
42	PIM:15, 36, 45, 65, 75 <sup>(4)</sup>	Vss	Digital Ground (DGND)
43	PIM:02, 16, 37, 46, 62, 86 <sup>(3)</sup>	VDD	Digital Power (DVDD)
44	PIM:50	RP65/PWM4H/RD1	Direct Connection
45	PIM:03	TMS/RP42/PWM3H/RB10	Direct Connection
46	PIM:100	TCK/RP43/PWM3L/RB11	Direct Connection
47	PIM:99	TDI/RP44/PWM2H/RB12	Direct Connection
48	PIM:98	RP45/PWM2L/RB13	Direct Connection

- Note 1:** The PIM pin is directly connected to the device pin through a 0 Ohm resistor (default), which can be removed if desired.
- 2:** The PIM pin can be connected to a device pin through a 0 Ohm resistor, if required. For proper operation, ensure that other 0 Ohm resistors connected to the same device pin are removed.
- 3:** Digital Power (DVDD) pins are shorted together on the PIM.
- 4:** Digital Ground (DGND) pins are shorted together on the PIM.
- 5:** Analog Ground (AGND) connection via PIM:31 is shorted with Digital Ground (DGND) through 0 Ohm resistor, R22, on the PIM.

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Table 3 provides mapping between the 100-pin PIM and the 48-pin device pinout.

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

PIM Pin #	Device Pin #	dsPIC33CK64MC105 Device Functional Description	Remarks
PIM:01	4	RP61/RC13	Direct Connection
PIM:02 <sup>(3)</sup>	18, 32, 43	VDD	Digital Power (DVDD)
PIM:03	45	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	—	—	Not Connected
PIM:11	—	—	Not Connected
PIM:12	—	—	Not Connected
PIM:13	5	MCLR	Direct Connection
PIM:14	—	—	Not Connected
PIM:15 <sup>(4)</sup>	19, 31, 42	VSS	Digital Ground (DGND)
PIM:16 <sup>(3)</sup>	18, 32, 43	VDD	Digital Power (DVDD)
PIM:17	—	—	Not Connected
PIM:18	30	RP72/SDO2/PCI19/RD8	Direct Connection
PIM:19	17	IBIAS1/RP54/RC6	Direct Connection
PIM:20	—	—	Not Connected
PIM:21	—	—	Not Connected
PIM:22	—	—	Not Connected
PIM:23	36	PGD1/AN10/RP40/SCL1/RB8	Direct Connection
PIM:24	35	TDO/AN2/RP39/RB7	Direct Connection
PIM:25	11	DACOUT/AN3/CMP1C/RA3	Direct Connection
PIM:26	34	PGC3/RP38/RB6	Direct Connection
PIM:27	33	PGD3/RP37/RB5	Direct Connection
PIM:28	—	External 1.65V Reference	External 1.65V Reference
PIM:29	—	—	Not Connected
PIM:30	13	AVDD	Analog Power (AVDD)
PIM:31 <sup>(5)</sup>	14	AVSS	Analog Ground (AGND)
PIM:32	20	AN15/IBIAS2/RP51/RC3	Direct Connection
PIM:33	—	—	Not Connected
PIM:34	—	—	Not Connected
PIM:35	7	AN12/RP48/RC0	Direct Connection
PIM:36 <sup>(4)</sup>	19, 31, 42	VSS	Digital Ground (DGND)
PIM:37 <sup>(3)</sup>	18, 32, 43	VDD	Digital Power (DVDD)
PIM:38	—	—	Not Connected
PIM:39	—	—	Not Connected

- Note 1:** The PIM pin is directly connected to the device pin through a 0 Ohm resistor (default), which can be removed if desired.
- 2:** The PIM pin can be connected to a device pin through a 0 Ohm resistor, if desired. For proper operation, ensure that other 0 Ohm resistors connected to the same device pin are removed.
- 3:** Digital Power (DVDD) pins are shorted together on the PIM.
- 4:** Digital Ground (DGND) pins are shorted together on the PIM.
- 5:** Analog Ground (AGND) connection via PIM:31 is shorted with Digital Ground (DGND) through 0 Ohm resistor, R22, on the PIM.

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

PIM Pin #	Device Pin #	dsPIC33CK64MC105 Device Functional Description	Remarks
PIM:40	—	—	Not Connected
PIM:41	—	—	Not Connected
PIM:42	—	—	Not Connected
PIM:43	—	—	Not Connected
PIM:44	—	—	Not Connected
PIM:45 <sup>(4)</sup>	19, 31, 42	VSS	Digital Ground (DGND)
PIM:46 <sup>(3)</sup>	18, 32, 43	VDD	Digital Power (DVDD)
PIM:47	6	ANN0/RP77/RD13	Direct Connection
PIM:48	23	ISRC3/RP74/RD10	Direct Connection
PIM:49	28	RP56/ASDA1/SCK2/RC8	Direct Connection
PIM:50	44	RP65/PWM4H/RD1	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	3	RP60/RC12	Direct Connection
PIM:61 <sup>(2)</sup>	40	RP58/RC10	Can be connected via 0 Ohm Resistor
PIM:62 <sup>(3)</sup>	18, 32, 43	VDD	Digital Power (DVDD)
PIM:63	21	OSCI/CLKI/AN5/RP32/RB0	Direct Connection
PIM:64	22	OSCO/CLKO/AN6/RP33/RB1	Direct Connection
PIM:65 <sup>(4)</sup>	19, 31, 42	VSS	Digital Ground (DGND)
PIM:66	9	OA1IN-/RA1	Op Amp Input
	16	OA3IN+/AN14/ISRC1/RP50/RC2	Op Amp Input
	26	PGD2/OA2IN-/AN8/RP35/RB3	Op Amp Input
PIM:67	15	OA3IN-/AN13/CMP1B/ISRC0/RP49/RC1	Op Amp Input
PIM:68	29	RP57/ASCL1/SDI2/RC9	Direct Connection
PIM:69	—	—	Not Connected
PIM:70	24	ISRC2/RP55/RC7	Direct Connection
PIM:71	—	—	Not Connected
PIM:72	—	—	Not Connected
PIM:73	27	PGC2/OA2IN+/RP36/RB4	Op Amp Input
PIM:74	10	OA1IN+/AN9/RA2	Op Amp Input
PIM:75 <sup>(4)</sup>	19, 31, 42	VSS	Digital Ground (DGND)
PIM:76	—	—	Not Connected
PIM:77	—	—	Not Connected
PIM:78 <sup>(1)</sup>	40	RP58/RC10	Connected via 0 Ohm Resistor
PIM:79	37	PGC1/AN11/RP41/SDA1/RB9	Direct Connection

- Note 1:** The PIM pin is directly connected to the device pin through a 0 Ohm resistor (default), which can be removed if desired.
- 2:** The PIM pin can be connected to a device pin through a 0 Ohm resistor, if desired. For proper operation, ensure that other 0 Ohm resistors connected to the same device pin are removed.
- 3:** Digital Power (DVDD) pins are shorted together on the PIM.
- 4:** Digital Ground (DGND) pins are shorted together on the PIM.
- 5:** Analog Ground (AGND) connection via PIM:31 is shorted with Digital Ground (DGND) through 0 Ohm resistor, R22, on the PIM.

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

PIM Pin #	Device Pin #	dsPIC33CK64MC105 Device Functional Description	Remarks
PIM:80	39	RP53/RC5	Direct Connection
PIM:81	—	—	Not Connected
PIM:82	—	—	Not Connected
PIM:83	41	RP59/RC11	Direct Connection
PIM:84	38	RP52/RC4	Direct Connection
PIM:85	—	—	Not Connected
PIM:86 <sup>(3)</sup>	18, 32, 43	VDD	Digital Power (DVDD)
PIM:87	—	—	Not Connected
PIM:88	—	—	Not Connected
PIM:89	—	—	Not Connected
PIM:90	—	—	Not Connected
PIM:91	—	—	Not Connected
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	—	—	Not Connected
PIM:98	48	RP45/PWM2L/RB13	Direct Connection
PIM:99	47	TDI/RP44/PWM2H/RB12	Direct Connection
PIM:100	46	TCK/RP43/PWM3L/RB11	Direct Connection

- Note 1:** The PIM pin is directly connected to the device pin through a 0 Ohm resistor (default), which can be removed if desired.
- Note 2:** The PIM pin can be connected to a device pin through a 0 Ohm resistor, if desired. For proper operation, ensure that other 0 Ohm resistors connected to the same device pin are removed.
- Note 3:** Digital Power (DVDD) pins are shorted together on the PIM.
- Note 4:** Digital Ground (DGND) pins are shorted together on the PIM.
- Note 5:** Analog Ground (AGND) connection via PIM:31 is shorted with Digital Ground (DGND) through 0 Ohm resistor, R22, on the PIM.

# dsPIC33CK64MC105

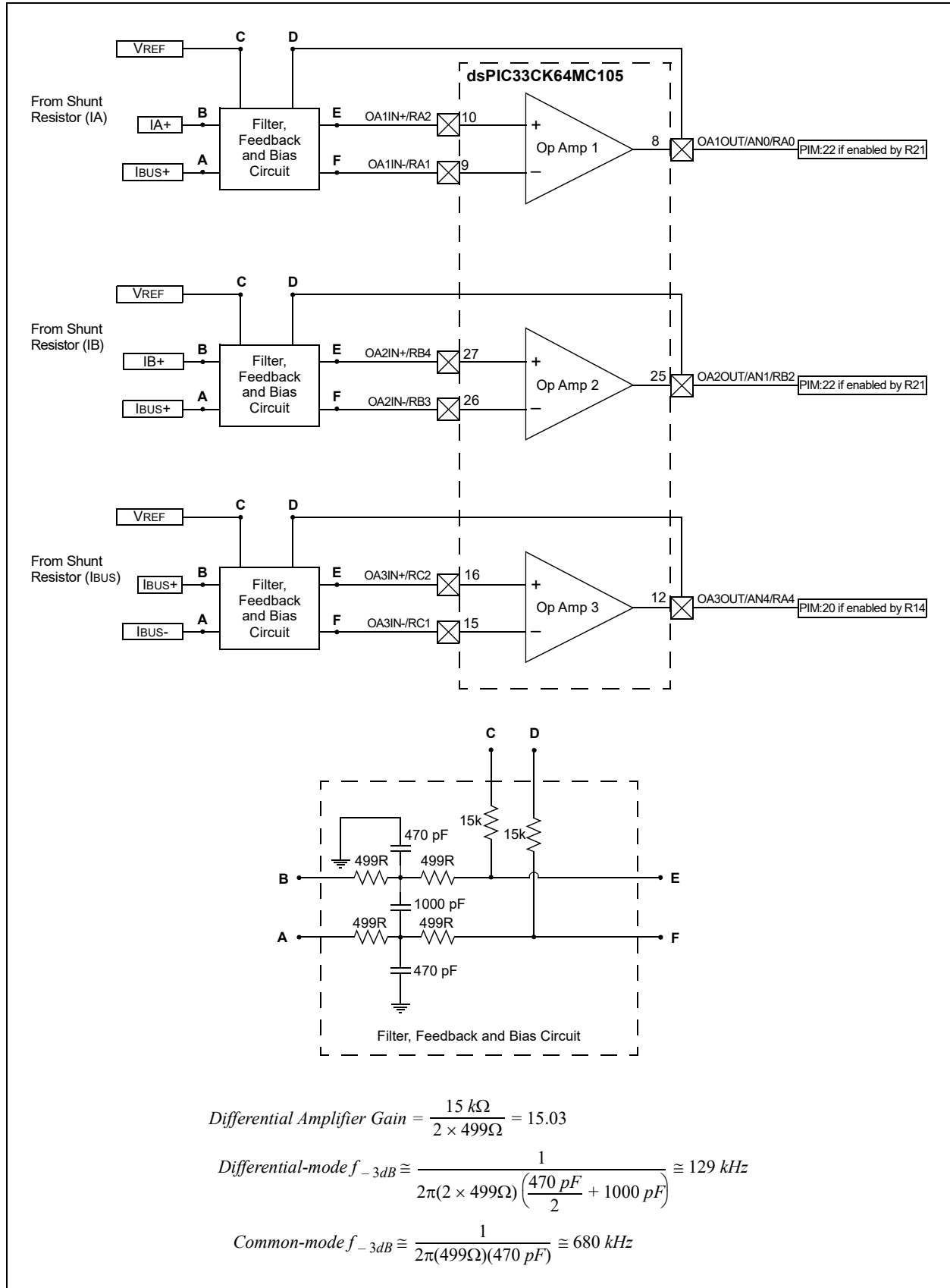
Table 4 classifies the passive components according to their functionality and quotes the design equations applicable in each case.

**TABLE 4: ANALOG FUNCTIONALITY LISTING**

Op Amp #	Analog Function	Passive Components	Design Equations
1	Low-Pass Filter	R15, R16, R17, R18, C12, C13, C14	$R15 = R16 = R17 = R18 = R$ $C12 = C14 = C$
	Reference Voltage Bias	R19, R20	$R19 = R20$
	Differential Amplifier Input	R15, R16, R17, R18	$Common-mode f_{-3dB} \cong \frac{1}{2\pi RC}$
	Differential Amplifier Feedback	R20	$Differential-mode f_{-3dB} \cong \frac{1}{2\pi(2R)\left(\frac{C}{2} + C13\right)}$  $Differential Amplifier Gain = \frac{R20}{2R}$
2	Low-Pass Filter	R1, R2, R3, R4, C6, C7, C8	$R1 = R2 = R3 = R4 = R$ $C6 = C8 = C$
	Reference Voltage Bias	R5, R6	$R5 = R6$
	Differential Amplifier Input	R1, R2, R3, R4	$Common-mode f_{-3dB} \cong \frac{1}{2\pi RC}$
	Differential Amplifier Feedback	R6	$Differential-mode f_{-3dB} \cong \frac{1}{2\pi(2R)\left(\frac{C}{2} + C7\right)}$  $Differential Amplifier Gain = \frac{R6}{2R}$
3	Low-Pass Filter	R8, R9, R10, R11, C9, C10, C11	$R8 = R9 = R10 = R11 = R$ $C9 = C11 = C$
	Reference Voltage Bias	R12, R13	$R12 = R13$
	Differential Amplifier Input	R8, R9, R10, R11	$Common-mode f_{-3dB} \cong \frac{1}{2\pi RC}$
	Differential Amplifier Feedback	R13	$Differential-mode f_{-3dB} \cong \frac{1}{2\pi(2R)\left(\frac{C}{2} + C10\right)}$  $Differential Amplifier Gain = \frac{R13}{2R}$



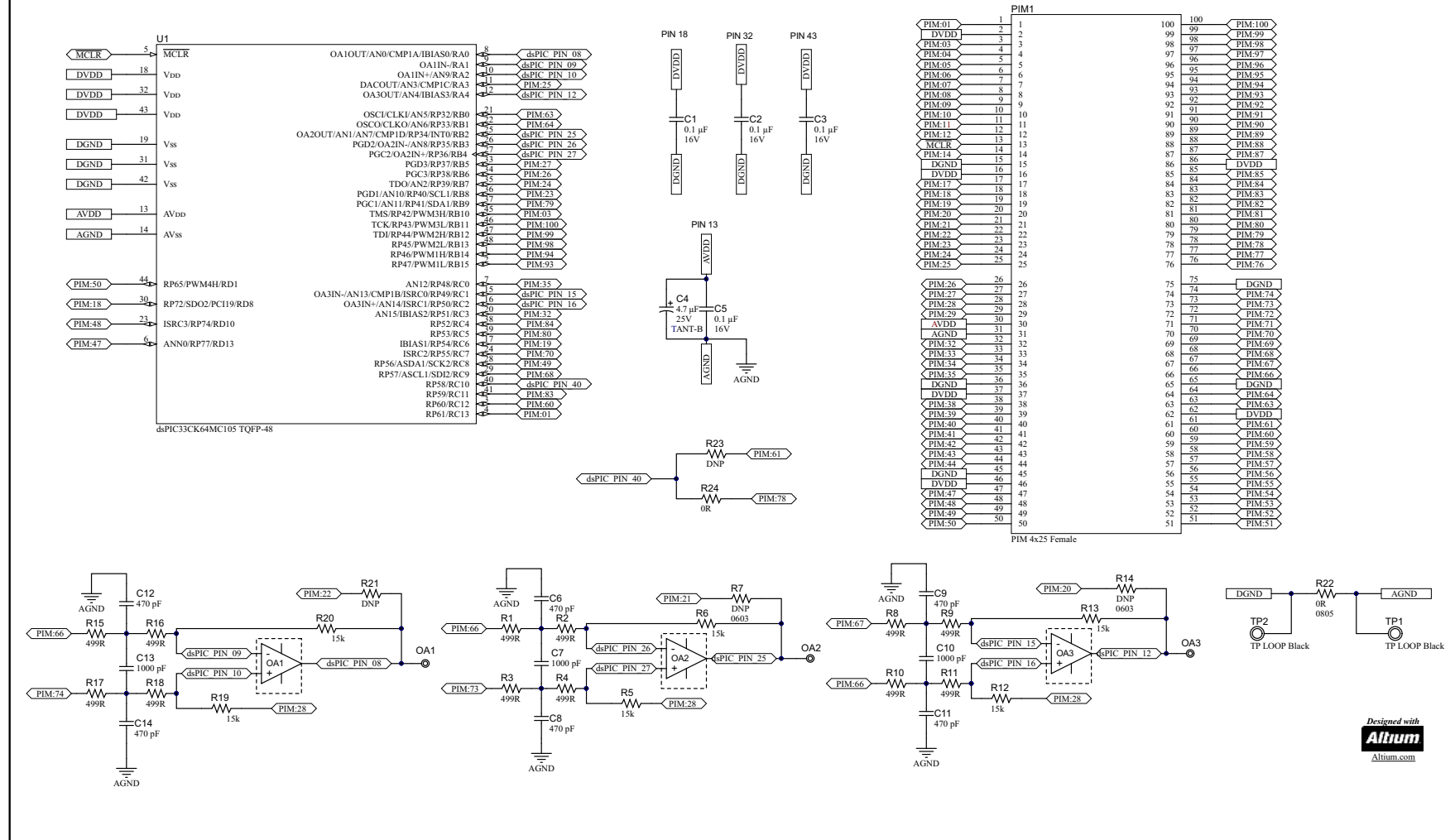
**FIGURE 3: INTERNAL OP AMP CONFIGURATION**



# dsPIC33CK64MC105 Motor Control Plug-In Module (PIM) for Internal Op Amp Configuration

## Schematic Revision 2.0

### dsPIC33CK64MC105 Internal Op Amp Motor Control PIM



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