dsPIC33CK256MP508

dsPIC33CK256MP508 Motor Control Plug-In Module (PIM) Information Sheet for Internal Op Amp Configuration

The dsPIC33CK256MP508 Internal Op Amp Motor Control PIM (P/N: MA330041-2) is designed to demonstrate the motor control capabilities of the dsPIC33CK256MP508 device using the internal op amps of the device.

The dsPIC33CK256MP508 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 (with fine edge placement) peripheral in the device. The PWM, along with other peripherals, such as the ADC, enable 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 on to the J4 header (as shown in Figure 2) on the board. The PIM design also supports dual motor control on the Low-Voltage Motor Control Bundle (DV330100).

For additional information regarding development boards, refer to the respective user's guides available on the Microchip web site (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: dsPIC33CK256MP508 INTERNAL OP AMP MOTOR CONTROL PIM (MA330041-2)
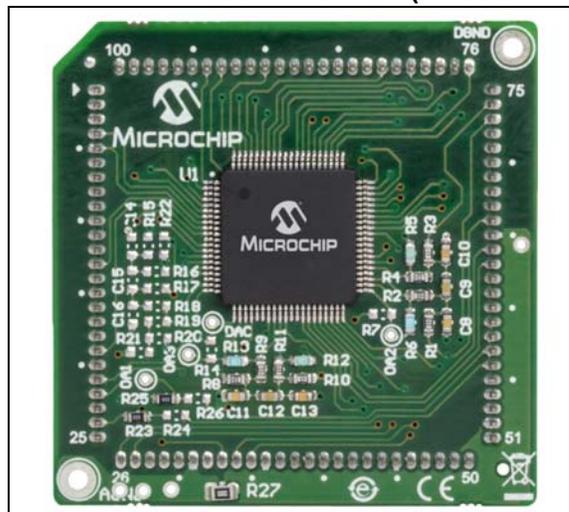
FIGURE 2: INTERNAL OP AMP CONFIGURATION BOARD

TABLE 1: HARDWARE COMPATIBILITY

Development Board	Part Number	Compatible Hardware Version(s)
dsPICDEM™ MCHV Development Board	DM330023	Not Compatible
dsPICDEM MCLV Development Board	DM330021	Not Compatible
dsPICDEM MCSM Development Board	DM330022	Not Compatible
dsPICDEM MCHV-3 Development Board	DM330023-3	All Revisions
dsPICDEM MCHV-2 Development Board	DM330023-2	All Revisions
dsPICDEM MCLV-2 Development Board	DM330021-2	All Revisions
Low-Voltage Motor Control Development Bundle	DV330100	All Revisions

Warning: Do not connect non-isolated oscilloscope probes to the test points on the PIM while using with the dsPICDEM MCHV-2 or MCHV-3 Development Board. Failure to heed this warning could result in hardware damage.

dsPIC33CK256MP508

Table 2 provides the mapping between the 80-pin device pinout and the 100-pin PIM.

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

Device Pin #	dsPIC33CK256MP508 Device Functional Description	PIM Pin #	Remarks
1	RP46/PWM1H/RB14	PIM:94	Direct Connection
2	AN20/RE0	PIM:22	Direct Connection
3	RP47/PWM1L/PMD6/RB15	PIM:93	Direct Connection
4	AN21/RE1	PIM:21	Direct Connection
5	RP60/PWM8H/PMD7/RC12	PIM:09	Direct Connection
6	RP61/PWM8L/PMA5/RC13	PIM:08	Direct Connection
7	RP62/PWM6H/PMA4/RC14	PIM:04	Direct Connection
8	RP63/PWM6L/PMA3/RC15	PIM:05	Direct Connection
9	$\overline{MCLR}$	PIM:13	$\overline{MCLR}$
10	RP79/PCI22/PMA2/RD15	PIM:19	Direct Connection
11	Vss	PIM:15, 36, 65, 75[4]	Digital Ground (DGND)
12	VDD	PIM:02, 16, 37, 62, 86[3]	Digital Power (DVDD)
13	RP78/PCI21/RD14	PIM:92	Direct Connection
14	ANN2/RP77/RD13	PIM:89	Direct Connection
15	AN12/ANN0/RP48/RC0	PIM:55	Direct Connection
16	OA1OUT/AN0/CMP1A/IBIAS0/RA0	PIM:25[1]	Connected via 0 Ohm Resistor
16	OA1OUT/AN0/CMP1A/IBIAS0/RA0	PIM:57[2]	Can be Connected via 0 Ohm Resistor
17	AN22/RE2	PIM:20	Direct Connection
18	OA1IN-/ANA1/RA1	PIM:24[1]	Connected via 0 Ohm Resistor
18	OA1IN-/ANA1/RA1	PIM:56[2]	Can be Connected via 0 Ohm Resistor
18	OA1IN-/ANA1/RA1	PIM:67	Optional Internal Op Amp Connection can be Connected to Op Amp 1 Input
19	AN23/RE3	PIM:33	Direct Connection
20	OA1IN+/AN9/PMA6/RA2	PIM:66	Optional Internal Op Amp Connection
21	DACOUT1/AN3/CMP1C/RA3	PIM:12	Direct Connection
22	RE4	PIM:69	Direct Connection
23	OA3OUT/AN4/CMP3B/IBIAS3/RA4	PIM:21[2]	Can be Connected via 0 Ohm Resistor
24	RE5	PIM:68	Direct Connection
25	AVDD	PIM:30	Analog Power (AVDD)
26	AVss	PIM:31[5]	Analog Ground (AGND)
27	RP76/RD12	PIM:85	Direct Connection
28	OA3IN-/AN13/CMP1B/ISRC0/RP49/PMA7/RC1	PIM:66	Internal Op Amp Connection
29	OA3IN+/AN14/CMP2B/ISRC1/RP50/PMD13/PMA13/RC2	PIM:73	Internal Op Amp Connection
30	AN17/ANN1/IBIAS1/RP54/PMD12/PMA12/RC6	PIM:43	Direct Connection
31	VDD	PIM:02, 16, 37, 62, 86[3]	Digital Power (DVDD)
32	Vss	PIM:15, 36, 65, 75[4]	Digital Ground (DGND)
33	AN15/CMP2A/IBIAS2/RP51/PMD11/PMA11/RC3	PIM:23	Direct Connection
34	OSCI/CLKI/AN5/RP32/PMD10/PMA10/RB0	PIM:63	Direct Connection
35	OSCO/CLKO/AN6/RP33/PMA1/PMALH/PSA1/RB1	PIM:64	Direct Connection
36	AN19/CMP2C/RP75/PMA0/PMALL/PSA0/RD11	PIM:32	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 connecting 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, R27, on the PIM.

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

Device Pin #	dsPIC33CK256MP508 Device Functional Description	PIM Pin #	Remarks
37	RE6	PIM:11	Direct Connection
38	AN18/CMP3C/ISRC3/RP74/PMD9/PMA9/RD10	PIM:35	Direct Connection
39	RE7	PIM:84	Direct Connection
40	AN16/ISRC2/RP55/PMD8/PMA8/RC7	PIM:79	Direct Connection
41	OA2OUT/AN1/AN7/ANA0/CMP1D/CMP2D/CMP3D/RP34/SCL3/INT0/RB2	PIM:22[2]	Can be Connected via 0 Ohm Resistor
42	RE8	PIM:60	Direct Connection
43	PGD2/OA2IN-/AN8/RP35/RB3	PIM:66	Internal Op Amp Connection
44	RE9	PIM:1	Direct Connection
45	PGC2/OA2IN+/RP36/RB4	PIM:74	Internal Op Amp Connection
46	RP56/ASDA1/SCK2/RC8	PIM:95	Direct Connection
47	RP57/ASCL1/SDI2/RC9	PIM:96	Direct Connection
48	RP73/PCI20/RD9	PIM:10	Direct Connection
49	RP72/SDO2/PCI19/RD8	PIM:18	Direct Connection
50	Vss	PIM:15, 36, 65, 75[4]	Digital Ground (DGND)
51	VDD	PIM:02, 16, 37, 62, 86[3]	Digital Power (DVDD)
52	RP71/PMD15/RD7	PIM:49	Direct Connection
53	RP70/PMD14/RD6	PIM:50	Direct Connection
54	RP69/PMA15/PMCS2/RD5	PIM:83	Direct Connection
55	PGD3/RP37/SDA2/PMA14/PMCS1/PSCS/RB5	PIM:27	Direct Connection
56	PGC3/RP38/SCL2/RB6	PIM:26	Direct Connection
57	RE10	PIM:40	Direct Connection
58	TDO/AN2/CMP3A/RP39/SDA3/RB7	PIM:14	Direct Connection
59	RE11	PIM:41	Direct Connection
60	PGD1/AN10/RP40/SCL1/RB8	PIM:17	Direct Connection
61	PGC1/AN11/RP41/SDA1/RB9	PIM:25	Direct Connection
62	RE12	PIM:59	Direct Connection
63	RP52/PWM5H/ASDA2/RC4	PIM:76	Direct Connection
64	RE13	PIM:34	Direct Connection
65	RP53/PWM5L/ASCL2/PMWR/PMENB/PSWR/RC5	PIM:54	Direct Connection
66	RP58/PWM7H/PMRD/PMWR/PSRD/RC10	PIM:07	Direct Connection
67	RP59/PWM7L/RC11	PIM:06	Direct Connection
68	RP68/ASDA3/RD4	PIM:61	Direct Connection
69	RP67/ASCL3/RD3	PIM:48	Direct Connection
70	Vss	PIM:15, 36, 65, 75[4]	Digital Ground (DGND)
71	VDD	PIM:02, 16, 37, 62, 86[3]	Digital Power (DVDD)
72	RP66/RD2	PIM:47	Direct Connection
73	RP65/PWM4H/RD1	PIM:80	Direct Connection
74	RP64/PWM4L/PMD0/RD0	PIM:78	Direct Connection
75	TMS/RP42/PWM3H/PMD1/RB10	PIM:03	Direct Connection
76	TCK/RP43/PWM3L/PMD2/RB11	PIM:100	Direct Connection
77	RE14	PIM:82	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 connecting 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, R27, on the PIM.

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

Device Pin #	dsPIC33CK256MP508 Device Functional Description	PIM Pin #	Remarks
78	TDI/RP44/PWM2H/PMD3/RB12	PIM:99	Direct Connection
79	RE15	PIM:90	Direct Connection
80	RP45/PWM2L/PMD4/RB13	PIM:98	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 connecting to the same device pin are removed.

3: Digital Power (DV$_{DD}$) 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, R27, on the PIM.

Table 3 provides the mapping between the 80-pin device pinout and the 100-pin PIM.

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

PIM Pin #	Device Pin #	dsPIC33CK256MP508 Device Functional Description	Remarks
PIM:01	44	RE9	Direct Connection
PIM:02[3]	12, 31, 51, 71	VDD	Digital Power (DVDD)
PIM:03	75	TMS/RP42/PWM3H/PMD1/RB10	Direct Connection
PIM:04	7	RP62/PWM6H/PMA4/RC14	Direct Connection
PIM:05	8	RP63/PWM6L/PMA3/RC15	Direct Connection
PIM:06	67	RP59/PWM7L/RC11	Direct Connection
PIM:07	66	RP58/PWM7H/PMRD/$\overline{PMWR}$/PSRD/RC10	Direct Connection
PIM:08	6	RP61/PWM8L/PMA5/RC13	Direct Connection
PIM:09	5	RP60/PWM8H/PMD7/RC12	Direct Connection
PIM:10	48	RP73/PCI20/RD9	Direct Connection
PIM:11	37	RE6	Direct Connection
PIM:12	21	DACOUT1/AN3/CMP1C/RA3	Direct Connection
PIM:13	9	$\overline{MCLR}$	$\overline{MCLR}$
PIM:14	58	TDO/AN2/CMP3A/RP39/SDA3/RB7	Direct Connection
PIM:15[4]	11, 32, 50, 70	VSS	Digital Ground (DGND)
PIM:16[3]	12, 31, 51, 71	VDD	Digital Power (DVDD)
PIM:17	60	PGD1/AN10/RP40/SCL1/RB8	Direct Connection
PIM:18	49	RP72/SDO2/PCI19/RD8	Direct Connection
PIM:19	10	RP79/PCI22/PMA2/RD15	Direct Connection
PIM:20	17	AN22/RE2	Direct Connection
PIM:21	4	AN21/RE1	Direct Connection
PIM:21[2]	23	OA3OUT/AN4/CMP3B/IBIAS3/RA4	Can be Connected via 0 Ohm Resistor
PIM:22	2	AN20/RE0	Direct Connection
PIM:22[2]	41	OA2OUT/AN1/AN7/ANA0/CMP1D/CMP2D/CMP3D/RP34/SCL3/INT0/RB2	Can be Connected via 0 Ohm Resistor
PIM:23	33	AN15/CMP2A/IBIAS2/RP51/PMD11/PMA11/RC3	Direct Connection
PIM:24[1]	18	OA1IN-/ANA1/RA1	Connected via 0 Ohm Resistor
PIM:25	61	PGC1/AN11/RP41/SDA1/RB9	Direct Connection
PIM:25[1]	16	OA1OUT/AN0/CMP1A/IBIAS0/RA0	Connected via 0 Ohm Resistor
PIM:26	56	PGC3/RP38/SCL2/RB6	Direct Connection
PIM:27	55	PGD3/RP37/SDA2/PMA14/PMCS1/PSCS/RB5	Direct Connection
PIM:28	—	—	Not Connected
PIM:29	—	—	Not Connected
PIM:30	25	AVDD	Analog Power (AVDD)
PIM:31[5]	26	AVSS	Analog Ground (AGND)
PIM:32	36	AN19/CMP2C/RP75/PMA0/PMALL/PSA0/RD11	Direct Connection
PIM:33	19	AN23/RE3	Direct Connection
PIM:34	64	RE13	Direct Connection
PIM:35	38	AN18/CMP3C/ISRC3/RP74/PMD9/PMA9/RD10	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 connecting 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, R27, on the PIM.

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

PIM Pin #	Device Pin #	dsPIC33CK256MP508 Device Functional Description	Remarks
PIM:36[4]	11, 32, 50, 70	Vss	Digital Ground (DGND)
PIM:37[3]	12, 31, 51, 71	Vdd	Digital Power (DVDD)
PIM:38	—	—	Not Connected
PIM:39	—	—	Not Connected
PIM:40	57	RE10	Direct Connection
PIM:41	59	RE11	Direct Connection
PIM:42	—	—	Not Connected
PIM:43	30	AN17/ANN1/IBIAS1/RP54/PMD12/PMA12/RC6	Direct Connection
PIM:44	—	—	Not Connected
PIM:45	—	—	Not Connected
PIM:46	—	—	Not Connected
PIM:47	72	RP66/RD2	Direct Connection
PIM:48	69	RP67/ASCL3/RD3	Direct Connection
PIM:49	52	RP71/PMD15/RD7	Direct Connection
PIM:50	53	RP70/PMD14/RD6	Direct Connection
PIM:51	—	—	Not Connected
PIM:52	—	—	Not Connected
PIM:53	—	—	Not Connected
PIM:54	65	RP53/PWM5L/ASCL2/PMWR/PMENB/PSWR/RC5	Direct Connection
PIM:55	15	AN12/ANN0/RP48/RC0	Direct Connection
PIM:56[2]	18	OA1IN-/ANA1/RA1	Can be Connected via 0 Ohm Resistor
PIM:57[2]	16	OA1OUT/AN0/CMP1A/IBIAS0/RA0	Can be Connected via 0 Ohm Resistor
PIM:58	—	—	Not Connected
PIM:59	62	RE12	Direct Connection
PIM:60	42	RE8	Direct Connection
PIM:61	68	RP68/ASDA3/RD4	Direct Connection
PIM:62[3]	12, 31, 51, 71	Vdd	Digital Power (DVDD)
PIM:63	34	OSCI/CLKI/AN5/RP32/PMD10/PMA10/RB0	Direct Connection
PIM:64	35	OSCO/CLKO/AN6/RP33/PMA1/PMALH/PSA1/RB1	Direct Connection
PIM:65[4]	11, 32, 50, 70	Vss	Digital Ground (DGND)
PIM:66	20, 28, 43	Op Amp Inputs (refer to Figure 2)	Internal Op Amp Connection
PIM:67	18	Op Amp Input (refer to Figure 2)	Internal Op Amp Connection
PIM:68	24	RE5	Direct Connection
PIM:69	22	RE4	Direct Connection
PIM:70	—	—	Not Connected
PIM:71	—	—	Not Connected
PIM:72	—	—	Not Connected
PIM:73	29	Op Amp Input (refer to Figure 2)	Internal Op Amp Connection
PIM:74	45	Op Amp Input (refer to Figure 2)	Internal Op Amp Connection
PIM:75[4]	11, 32, 50, 70	Vss	Digital Ground (DGND)
PIM:76	63	RP52/PWM5H/ASDA2/RC4	Direct Connection
PIM:77	—	—	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 required. For proper operation, ensure that other 0 Ohm resistors connecting 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, R27, on the PIM.

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

PIM Pin #	Device Pin #	dsPIC33CK256MP508 Device Functional Description	Remarks
PIM:78	74	RP64/PWM4L/PMD0/RD0	Direct Connection
PIM:79	40	AN16/ISRC2/RP55/PMD8/PMA8/RC7	Direct Connection
PIM:80	73	RP65/PWM4H/RD1	Direct Connection
PIM:81	—	—	Not Connected
PIM:82	77	RE14	Direct Connection
PIM:83	54	RP69/PMA15/PMCS2/RD5	Direct Connection
PIM:84	39	RE7	Direct Connection
PIM:85	27	RP76/RD12	Direct Connection
PIM:86[3]	12, 31, 51, 71	V_{DD}	Digital Power (DV$_{DD}$)
PIM:87	—	—	Not Connected
PIM:88	—	—	Not Connected
PIM:89	14	ANN2/RP77/RD13	Direct Connection
PIM:90	79	RE15	Direct Connection
PIM:91	—	—	Not Connected
PIM:92	13	RP78/PCI21/RD14	Direct Connection
PIM:93	3	RP47/PWM1L/PMD6/RB15	Direct Connection
PIM:94	1	RP46/PWM1H/PMD5/RB14	Direct Connection
PIM:95	46	RP56/ASDA1/SCK2/RC8	Direct Connection
PIM:96	47	RP57/ASCL1/SDI2/RC9	Direct Connection
PIM:97	—	—	Not Connected
PIM:98	80	RP45/PWM2L/PMD4/RB13	Direct Connection
PIM:99	78	TDI/RP44/PWM2H/PMD3/RB12	Direct Connection
PIM:100	76	TCK/RP43/PWM3L/PMD2/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.

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 connecting to the same device pin are removed.

3: Digital Power (DV$_{DD}$) 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, R27, on the PIM.

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

Op Amp 1, as seen in Figure 3, is not used by default. If the filter, bias and feedback circuit section are populated, and configured by software, it can be used to amplify the I$_{BUS}$ current. Prior to using Op Amp 1, the resistor jumpers, R23, R24, R25, R26, should be removed to enable I$_{BUS}$ current to use the Op Amp 1 inputs. As a result, this limits the Power Factor Correction (PFC) functionality in the case of MCHV-2 or Field Oriented Control (FOC) on Inverter B of the Low-Voltage Motor Control Development Bundle.

TABLE 4: ANALOG FUNCTIONALITY LISTING

Op Amp #	Analog Function	Passive Components	Design Equations
1	Low-Pass Filter	R15, R16, R17, R18, C14, C15, C16	$R15 = R16 = R17 = R18 = R$ $C14 = C16 = C$ $R10 = R11$ $Common\text{-}mode\ f_{-3\,dB} \cong \dfrac{1}{2\pi RC}$ $Differential\text{-}mode\ f_{-3\,dB} \cong \dfrac{1}{2\pi(2R)\left(\dfrac{C}{2} + C15\right)}$ $Differential\ Amplifier\ Gain = \dfrac{R22}{2R}$
	Reference Voltage Bias	R19, R20, R21, R22	
	Voltage Divider	R20, R21	
	Differential Amplifier Input	R15, R16, R17, R18	
	Differential Amplifier Feedback	R22	
2	Low-Pass Filter	R1, R2, R3, R4, C8, C9, C10	$R1 = R2 = R3 = R4 = R$ $C8 = C110 = C$ $R5 = R6$ $Common\text{-}mode\ f_{-3\,dB} \cong \dfrac{1}{2\pi RC}$ $Differential\text{-}mode\ f_{-3\,dB} \cong \dfrac{1}{2\pi(2R)\left(\dfrac{C}{2} + C9\right)}$ $Differential\ Amplifier\ Gain = \dfrac{R6}{2R}$
	Reference Voltage Bias	R5, R6	
	Differential Amplifier Input	R1, R2, R3, R4	
	Differential Amplifier Feedback	R6	
3	Low-Pass Filter	R8, R9, R10, R11, C11, C12, C13	$R8 = R9 = R10 = R11 = R$ $C11 = C13 = C$ $R12 = R13$ $Common\text{-}mode\ f_{-3\,dB} \cong \dfrac{1}{2\pi RC}$ $Differential\text{-}mode\ f_{-3\,dB} \cong \dfrac{1}{2\pi(2R)\left(\dfrac{C}{2} + C12\right)}$ $Differential\ Amplifier\ Gain = \dfrac{R13}{2R}$
	Reference Voltage Bias	R12, R13	
	Differential Amplifier Input	R8, R9, R10, R11	
	Differential Amplifier Feedback	R13	

FIGURE 3: **INTERNAL OP AMP CONFIGURATION**
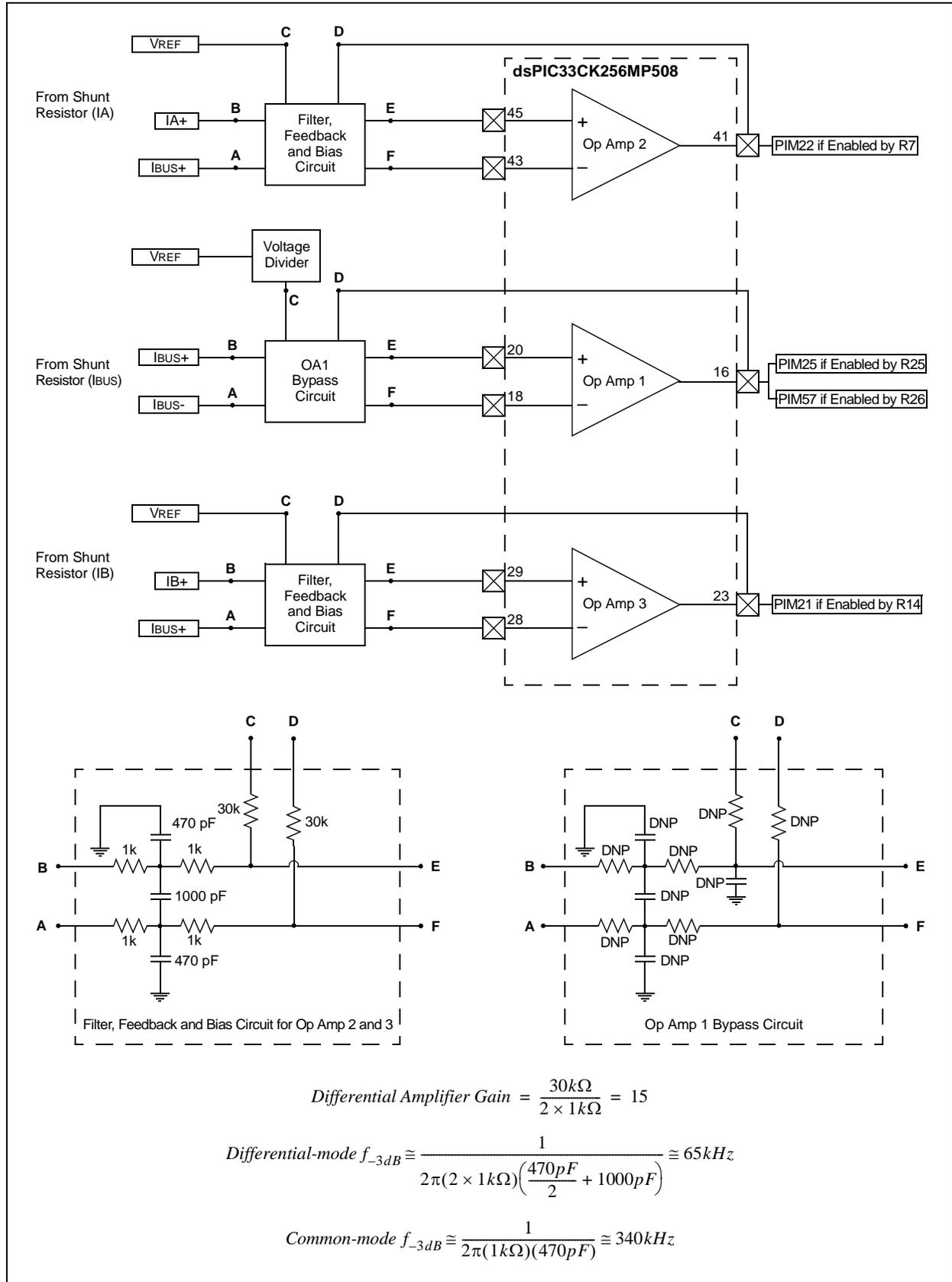
$$Differential\ Amplifier\ Gain\ =\ \frac{30k\Omega}{2 \times 1k\Omega}\ =\ 15$$

$$Differential\text{-}mode\ f_{-3dB} \cong \frac{1}{2\pi(2 \times 1k\Omega)\left(\frac{470pF}{2} + 1000pF\right)} \cong 65kHz$$

$$Common\text{-}mode\ f_{-3dB} \cong \frac{1}{2\pi(1k\Omega)(470pF)} \cong 340kHz$$

dsPIC33CK256MP508 Motor Control Plug-In Module (PIM) Information Sheet for Internal Op Amp Configuration

Schematic Revision 1.0

dsPIC33CK256MP508 Internal Op Amp Motor Control PIM
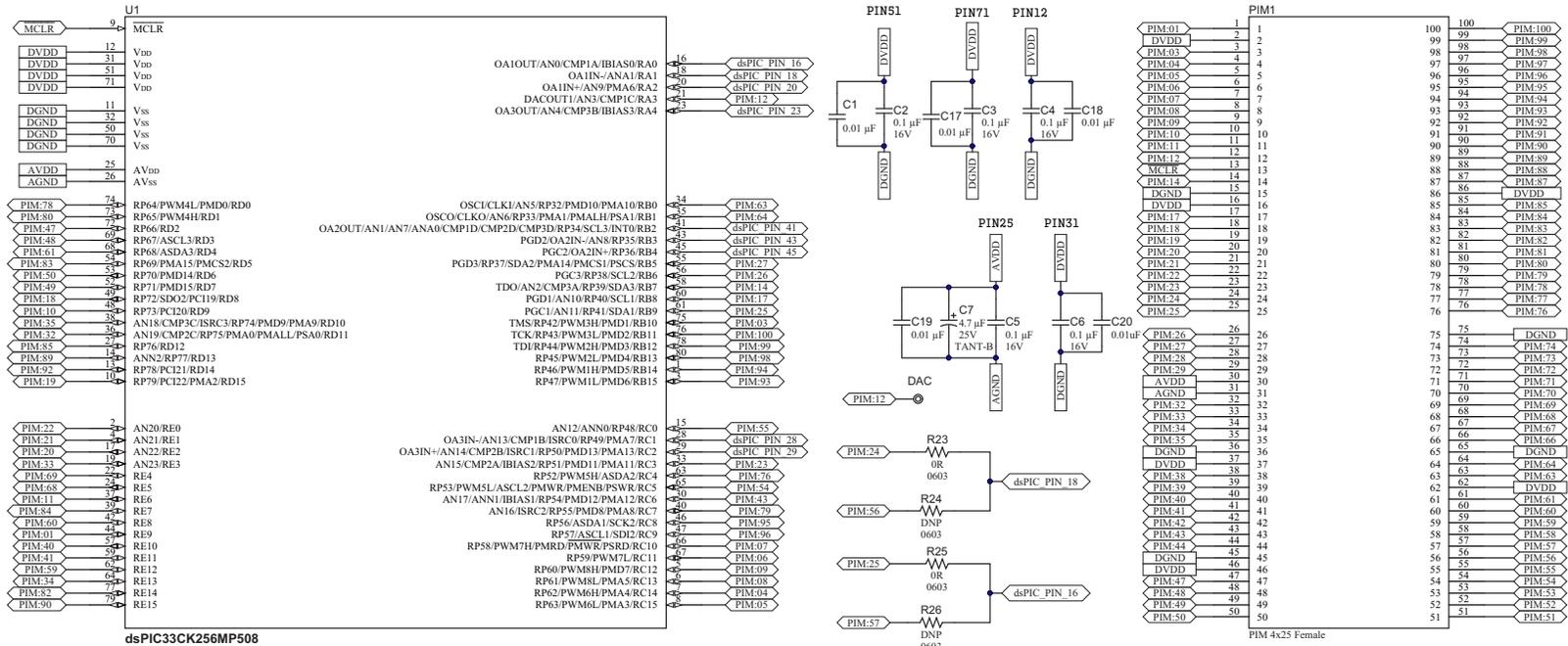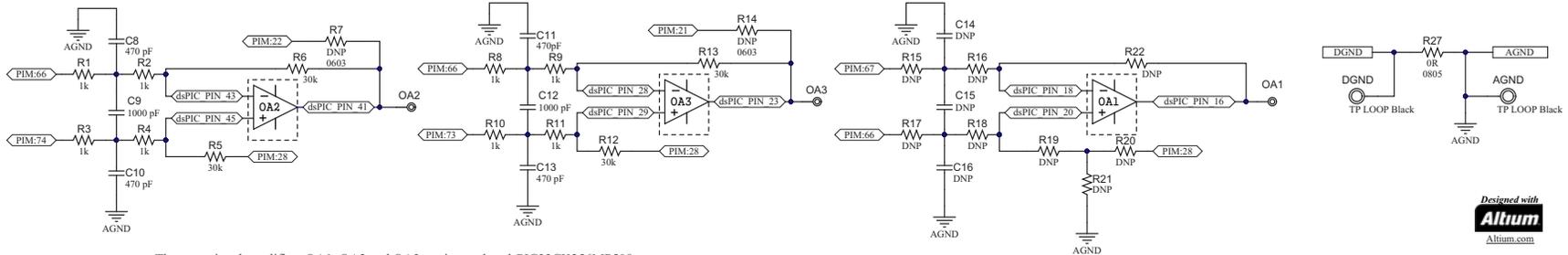
The operational amplifiers OA1, OA2 and OA3 are internal to dsPIC33CK256MP508

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Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.

- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.

- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.

- Microchip is willing to work with the customer who is concerned about the integrity of their code.

- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

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