dsPIC33CK64MC105

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).

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)**
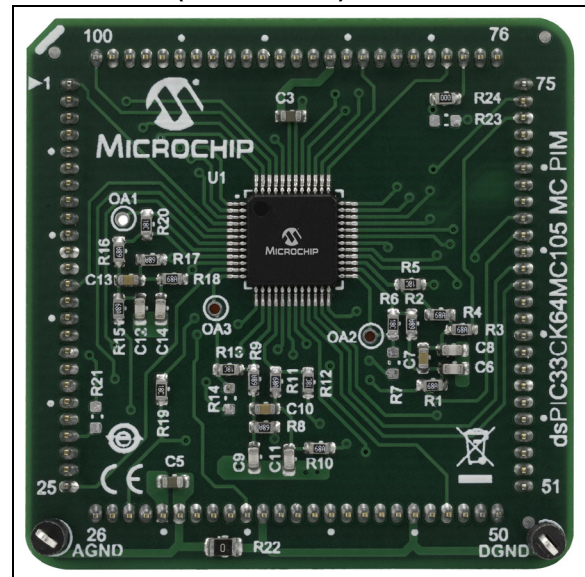

FIGURE 2: **INTERNAL OP AMP CONFIGURATION BOARD**

dsPIC33CK64MC105

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
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.

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	AV$_{DD}$	Analog Power (AV$_{DD}$)
14	PIM:31[5]	AV$_{SS}$	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[3]	V$_{DD}$	Digital Power (DV$_{DD}$)
19	PIM:15, 36, 45, 65, 75[4]	V$_{SS}$	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[4]	V$_{SS}$	Digital Ground (DGND)
32	PIM:02, 16, 37, 46, 62, 86[3]	V$_{DD}$	Digital Power (DV$_{DD}$)
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.

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 (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, R22, on the PIM.

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[2]	RP58/RC10	Can be connected via 0 Ohm Resistor
	PIM:78[1]		Connected via 0 Ohm Resistor
41	PIM:83	RP59/RC11	Direct Connection
42	PIM:15, 36, 45, 65, 75[4]	Vss	Digital Ground (DGND)
43	PIM:02, 16, 37, 46, 62, 86[3]	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.

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[3]	18, 32, 43	V$_{DD}$	Digital Power (DV$_{DD}$)
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	$\overline{\text{MCLR}}$	Direct Connection
PIM:14	—	—	Not Connected
PIM:15[4]	19, 31, 42	V$_{SS}$	Digital Ground (DGND)
PIM:16[3]	18, 32, 43	V$_{DD}$	Digital Power (DV$_{DD}$)
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	AV$_{DD}$	Analog Power (AV$_{DD}$)
PIM:31[5]	14	AV$_{SS}$	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[4]	19, 31, 42	V$_{SS}$	Digital Ground (DGND)
PIM:37[3]	18, 32, 43	V$_{DD}$	Digital Power (DV$_{DD}$)
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 (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, R22, on the PIM.

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[4]	19, 31, 42	Vss	Digital Ground (DGND)
PIM:46[3]	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[2]	40	RP58/RC10	Can be connected via 0 Ohm Resistor
PIM:62[3]	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[4]	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[4]	19, 31, 42	Vss	Digital Ground (DGND)
PIM:76	—	—	Not Connected
PIM:77	—	—	Not Connected
PIM:78[1]	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.

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[3]	18, 32, 43	V_{DD}	Digital Power (DV$_{DD}$)
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.

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 (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, R22, on the PIM.
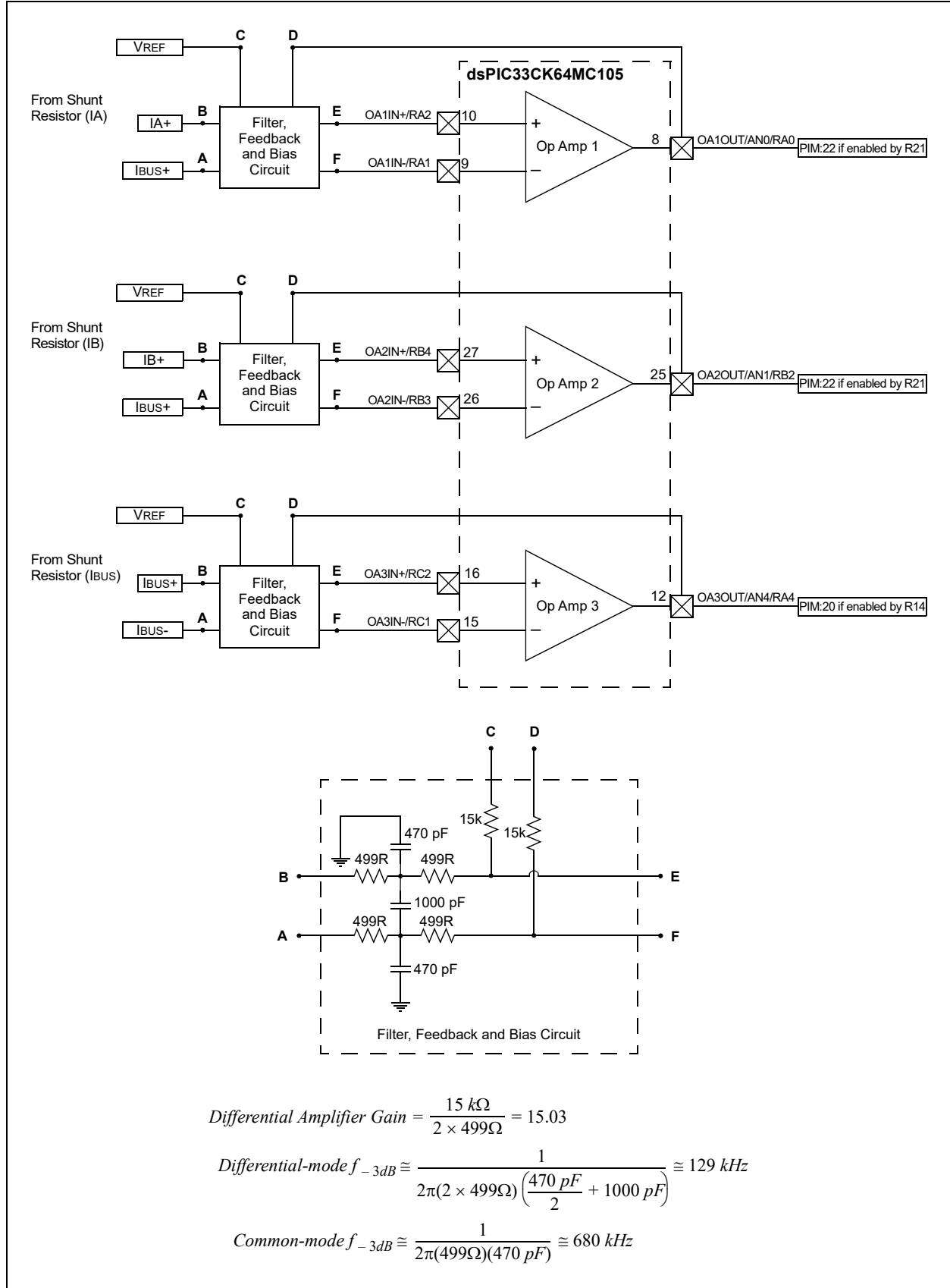
dsPIC33CK64MC105

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

TABLE 4: ANALOG FUNCTIONALITY LISTING

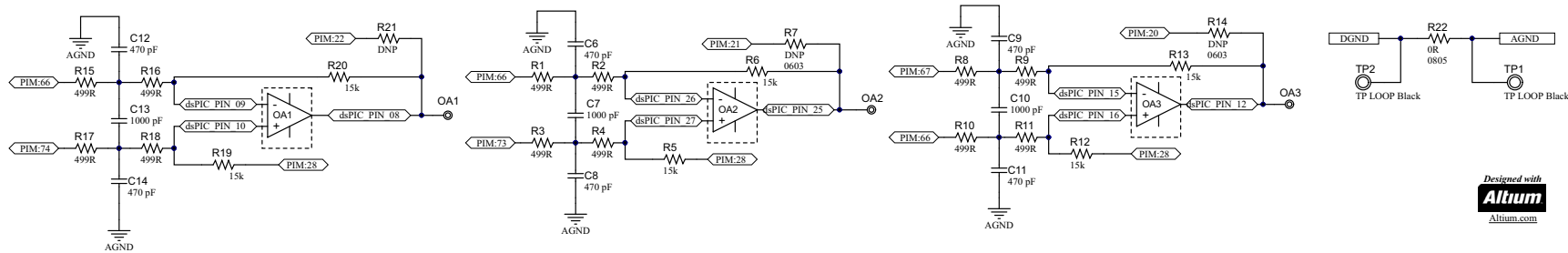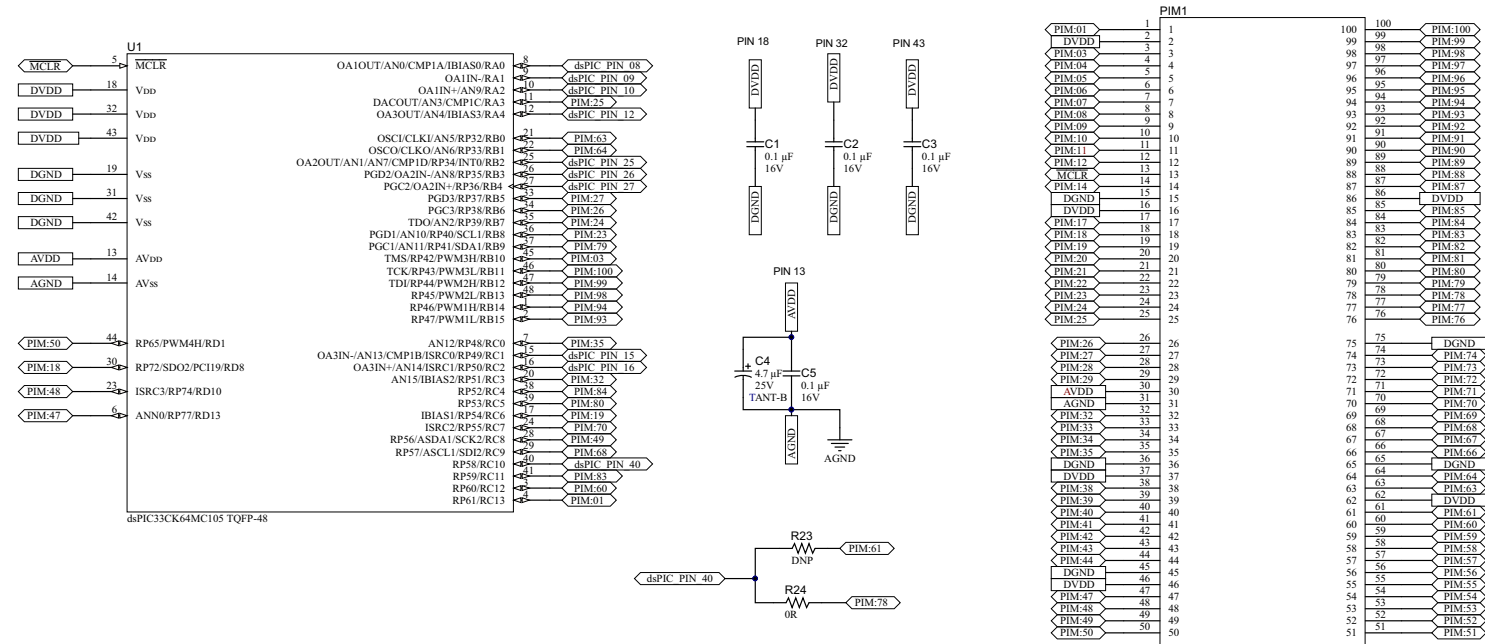| Op Amp #	Analog Function	Passive Components	Design Equations
1	Low-Pass Filter	R15, R16, R17, R18, C12, C13, C14	$R15 = R16 = R17 = R18 = R$ $C12 = C14 = C$ $R19 = R20$ $Common\text{-}mode\, f_{-3\,dB} \cong \dfrac{1}{2\pi RC}$ $Differential\text{-}mode\, f_{-3\,dB} \cong \dfrac{1}{2\pi(2R)\left(\dfrac{C}{2}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

FIGURE 3: **INTERNAL OP AMP CONFIGURATION**

$$Differential\ Amplifier\ Gain = \frac{15\ k\Omega}{2 \times 499\Omega} = 15.03$$

$$Differential\text{-}mode\ f_{-3dB} \cong \frac{1}{2\pi(2 \times 499\Omega)\left(\frac{470\ pF}{2} + 1000\ pF\right)} \cong 129\ kHz$$

$$Common\text{-}mode\ f_{-3dB} \cong \frac{1}{2\pi(499\Omega)(470\ pF)} \cong 680\ kHz$$

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

Schematic Revision 2.0

dsPIC33CK64MC105 Internal Op Amp Motor Control PIM

U1 — dsPIC33CK64MC105 TQFP-48

Left side inputs:
- MCLR — 5 — MCLR
- DVDD — 18 — VDD
- DVDD — 32 — VDD
- DVDD — 43 — VDD
- DGND — 19 — Vss
- DGND — 31 — Vss
- DGND — 42 — Vss
- AVDD — 13 — AVDD
- AGND — 14 — AVss
- PIM:50 — 44 — RP65/PWM4H/RD1
- PIM:18 — 30 — RP72/SDO2/PCI19/RD8
- PIM:48 — 23 — ISRC3/RP74/RD10
- PIM:47 — 6 — ANN0/RP77/RD13

Right side pin signals (U1):
- OA1OUT/AN0/CMP1A/IBIAS0/RA0 — 8 — dsPIC_PIN_08
- OA1IN-/RA1 — 9 — dsPIC_PIN_09
- OA1IN+/AN9/RA2 — 10 — dsPIC_PIN_10
- DACOUT/AN3/CMP1C/RA3 — 11 — PIM:25
- OA3OUT/AN4/IBIAS3/RA4 — 12 — dsPIC_PIN_12
- OSCI/CLKI/AN5/RP32/RB0 — 21 — PIM:63
- OSCO/CLKO/AN6/RP33/RB1 — 22 — PIM:64
- OA2OUT/AN1/AN7/CMP1D/RP34/INT0/RB2 — 25 — dsPIC_PIN_25
- PGD2/OA2IN-/AN8/RP35/RB3 — 26 — dsPIC_PIN_26
- PGC2/OA2IN+/RP36/RB4 — 27 — dsPIC_PIN_27
- PGD3/RP37/RB5 — 53 — PIM:27
- PGC3/RP38/RB6 — 54 — PIM:26
- TDO/AN2/RP39/RB7 — 55 — PIM:24
- PGD1/AN10/RP40/SCL1/RB8 — 56 — PIM:23
- PGC1/AN11/RP41/SDA1/RB9 — 57 — PIM:79
- TMS/RP42/PWM3H/RB10 — 45 — PIM:03
- TCK/RP43/PWM3L/RB11 — 46 — PIM:100
- TDI/RP44/PWM2H/RB12 — 47 — PIM:99
- RP45/PWM2L/RB13 — 38 — PIM:98
- RP46/PWM1H/RB14 — 39 — PIM:94
- RP47/PWM1L/RB15 — 40 — PIM:93
- AN12/RP48/RC0 — 7 — PIM:35
- OA3IN-/AN13/CMP1B/ISRC0/RP49/RC1 — 15 — dsPIC_PIN_15
- OA3IN+/AN14/ISRC1/RP50/RC2 — 16 — dsPIC_PIN_16
- AN15/IBIAS2/RP51/RC3 — 20 — PIM:32
- RP52/RC4 — 50 — PIM:84
- RP53/RC5 — 51 — PIM:80
- IBIAS1/RP54/RC6 — 52 — PIM:19
- ISRC2/RP55/RC7 — 58 — PIM:70
- RP56/ASDA1/SCK2/RC8 — 59 — PIM:49
- RP57/ASCL1/SDI2/RC9 — 60 — PIM:68
- RP58/RC10 — 40 — dsPIC_PIN_40
- RP59/RC11 — 61 — PIM:83
- RP60/RC12 — 62 — PIM:60
- RP61/RC13 — 63 — PIM:01

PIN 18 — DVDD — C1 — 0.1 µF — 16V — DGND
PIN 32 — DVDD — C2 — 0.1 µF — 16V — DGND
PIN 43 — DVDD — C3 — 0.1 µF — 16V — DGND

PIN 13 — AVDD — C4 — 4.7 µF — 25V — TANT-B — C5 — 0.1 µF — 16V — AGND

R23 — DNP — PIM:61
dsPIC_PIN_40
R24 — 0R — PIM:78

PIM1 — PIM 4x25 Female

Left column (pins 1–50):
PIM:01, DVDD, PIM:03, PIM:04, PIM:05, PIM:06, PIM:07, PIM:08, PIM:09, PIM:10, PIM:11, PIM:12, MCLR, PIM:14, DGND, DVDD, PIM:17, PIM:18, PIM:19, PIM:20, PIM:21, PIM:22, PIM:23, PIM:24, PIM:25, PIM:26, PIM:27, PIM:28, PIM:29, AVDD, AGND, PIM:32, PIM:33, PIM:34, PIM:35, DGND, DVDD, PIM:38, PIM:39, PIM:40, PIM:41, PIM:42, PIM:43, PIM:44, DGND, DVDD, PIM:47, PIM:48, PIM:49, PIM:50

Right column (pins 51–100):
PIM:51, PIM:52, PIM:53, PIM:54, PIM:55, PIM:56, PIM:57, PIM:58, PIM:59, PIM:60, PIM:61, DVDD, PIM:63, PIM:64, DGND, PIM:66, PIM:67, PIM:68, PIM:69, PIM:70, PIM:71, PIM:72, PIM:73, DGND, PIM:76, PIM:77, PIM:78, PIM:79, PIM:80, PIM:81, PIM:82, PIM:83, PIM:84, PIM:85, DVDD, PIM:87, PIM:88, PIM:89, PIM:90, PIM:91, PIM:92, PIM:93, PIM:94, PIM:95, PIM:96, PIM:97, PIM:98, PIM:99, PIM:100

Op Amp OA1 circuit:
- AGND — C12 — 470 pF
- PIM:66 — R15 — 499R
- R16 — 499R
- C13 — 1000 pF
- PIM:74 — R17 — 499R
- R18 — 499R
- C14 — 470 pF — AGND
- dsPIC_PIN_09
- dsPIC_PIN_10
- R19 — 15k — PIM:28
- OA1
- PIM:22 — R21 — DNP
- R20 — 15k
- dsPIC_PIN_08 — OA1

Op Amp OA2 circuit:
- AGND — C6 — 470 pF
- PIM:66 — R1 — 499R
- R2 — 499R
- C7 — 1000 pF
- PIM:73 — R3 — 499R
- R4 — 499R
- C8 — 470 pF — AGND
- dsPIC_PIN_26
- dsPIC_PIN_27
- R5 — 15k — PIM:28
- OA2
- PIM:21 — R7 — DNP — 0603
- R6 — 15k
- dsPIC_PIN_25 — OA2

Op Amp OA3 circuit:
- AGND — C9 — 470 pF
- PIM:67 — R8 — 499R
- R9 — 499R
- C10 — 1000 pF
- PIM:66 — R10 — 499R
- R11 — 499R
- C11 — 470 pF — AGND
- dsPIC_PIN_15
- dsPIC_PIN_16
- R12 — 15k — PIM:28
- OA3
- PIM:20 — R14 — DNP — 0603
- R13 — 15k
- dsPIC_PIN_12 — OA3

Test points:
- DGND — R22 — 0R — 0805 — AGND
- TP2 — TP LOOP Black
- TP1 — TP LOOP Black

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

• Microchip products meet the specifications contained in their particular Microchip Data Sheet.

• Microchip believes that its family of products is secure when used in the intended manner and under normal conditions.

• There are dishonest and possibly illegal methods being used in attempts to breach the code protection features of the Microchip devices. We believe that these methods require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Attempts to breach these code protection features, most likely, cannot be accomplished without violating Microchip's intellectual property rights.

• Microchip is willing to work with any customer who is concerned about the integrity of its code.

• Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable." Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

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