

# IMC300A Data Sheet

## Motor control IC series with an additional microcontroller

### Features

#### Dual core computation – Motion Control Engine (MCE) and ARM® Cortex®-M0 based user application controller (MCU)

#### Motion Control Engine (MCE)

- MCE offers a ready-to-use solution with easy configuration for variable speed motor control
  - Space Vector PWM with sinusoidal commutation and integrated protection features
  - Current sensing via single or leg shunt configuration
  - Sensorless and/or hall sensor (analog/digital) based operation
  - Integrated and/or external temperature sensor
  - Optional boost or totem pole PFC control
  - Integrated Script language for additional MCE and I/O control.
  - Flexible host interface options for motor control command: user UART, JCOM
  - High speed communication interface between MCE and ARM® core processor (JCOM)
  - Parameter programming and debug support with MCEWizard and MCEDesigner

#### User Application Controller

- CPU Subsystem
  - 32-bit Arm® Cortex®-M0 core for user application control
  - 48/96 MHz core/peripherals clock
  - Nested Vectored Interrupt Controller (NVIC)
  - Event Request Unit (ERU) for event interconnections
  - MATH Co-processor: 24-bit trigonometric calculation (CORDIC), 32-bit division unit
- On-Chip Memories
  - 8 Kbyte ROM
  - 16 Kbyte SRAM (with parity)
  - 128 Kbyte FLASH memory (with ECC)
- Supply, Reset and Clock
  - 3.3 V to 5.5 V supply with power on reset and brownout detector
  - On-chip clock monitor
  - Internal slow and fast oscillators
  - External crystal oscillator support (32 kHz and 4 to 20 MHz)
- System Control
  - Window watchdog
  - Real Time Clock (RTC) module
  - Pseudo random number generator

**About this document**

- Communication Peripherals
  - Universal Serial Interface Channels (USIC), usable as UART, double-SPI, IIC, IIS and LIN interfaces
  - MultiCAN+, Full-CAN/Basic-CAN with 2 nodes, 32 message objects (up to 1 Mbaud)
- Analog Frontend Peripherals
  - 12-bit ADC converter with adjustable gain, up to 1 MS/s and up to 7 analog inputs
  - 0 V to 5.5 V input voltage range
  - 2 fast analog comparators
  - DAC with one-bit sigma-delta generator, external low-pass filter and up to 7 outputs
  - Temperature sensor
- High Speed Timers
  - 2x Capture Compare Unit with 4 timer channels each (CCU4)
  - Clock up to 96 MHz
  - Up to 8 capture inputs
  - Up to 8 PWM outputs (center/edge aligned)
- Input/Output Lines With Individual Bit Controllability
  - Tri-stated in input mode
  - Push/pull or open drain output mode
  - Configurable pad hysteresis
- Debug System
  - 4 breakpoints, 2 watchpoints
  - ARM serial wire debug (SWD), single-pin debug (SPD) interfaces
  - Independent operation of the MCE

**Potential applications**

- AirConditioner
- Refrigerators

**Product validation**

Industrial

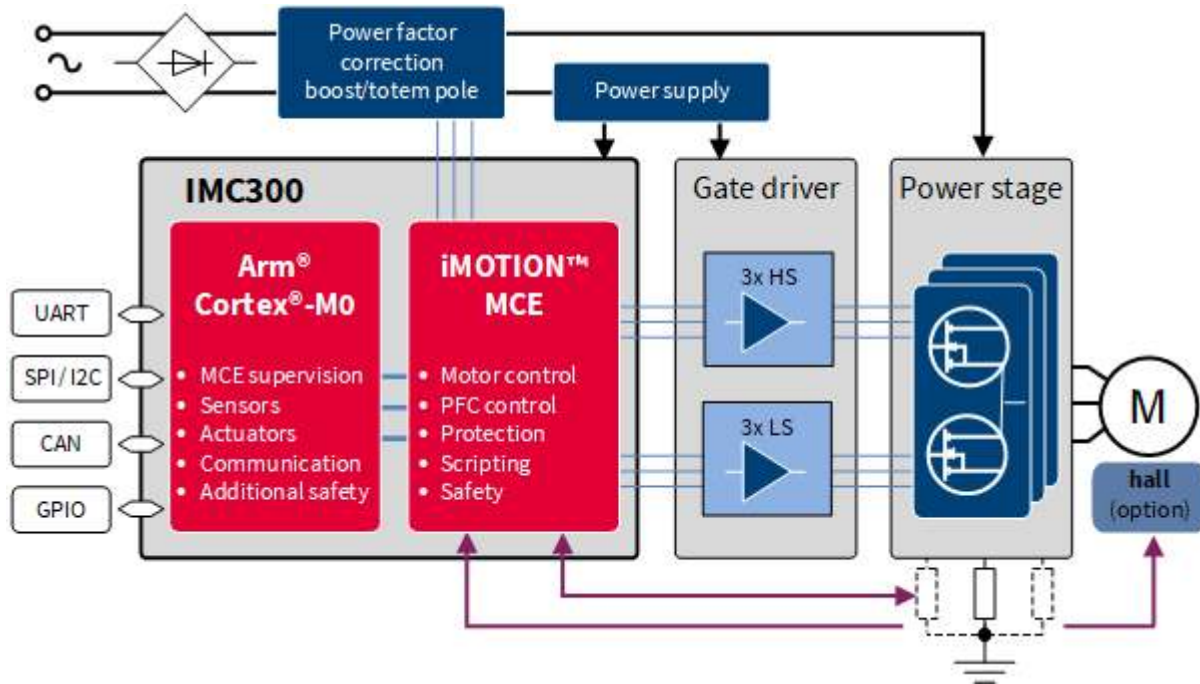
**Ordering Information**

Product Type	Application	Package
IMC301A-F048	Single motor	LQFP-48
IMC301A-F064		LQFP-64
IMC302A-F048	Single motor + PFC (boost, totem pole)	LQFP-48
IMC302A-F064		LQFP-64

About this document

Description

iMOTION™ IMC300 is a family of highly integrated ICs for the control of variable speed motor control system with an additional user programmable microcontroller. By integrating the required hardware, software and user program to perform control of a permanent magnet synchronous motor (PMSM) it offers a high flexibility of motor control system at the lowest system and development cost.



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**About this document**

## **About this document**

### **Scope and purpose**

This Datasheet describes the mechanical, electrical and functional characteristics of the iMOTION™ IMC300 series of motor control ICs. If no specific device is given the characteristics are valid for all devices within the iMOTION™ IMC300 series. For a detailed description of the functionality and configuration options please refer to the device HW reference manual and the relevant MCE SW reference manual.

### **Intended audience**

The Datasheet is targeting developers implementing a variable speed drive system.

Block Diagram Reference

# 1 Block Diagram Reference

The block diagram below gives an overview on the available functional units in the iMOTION™ IMC300 family. Not all units are required in all applications and some modules might share pins in smaller packages. Please refer to the pin configuration for the individual packages and the application schematic examples given

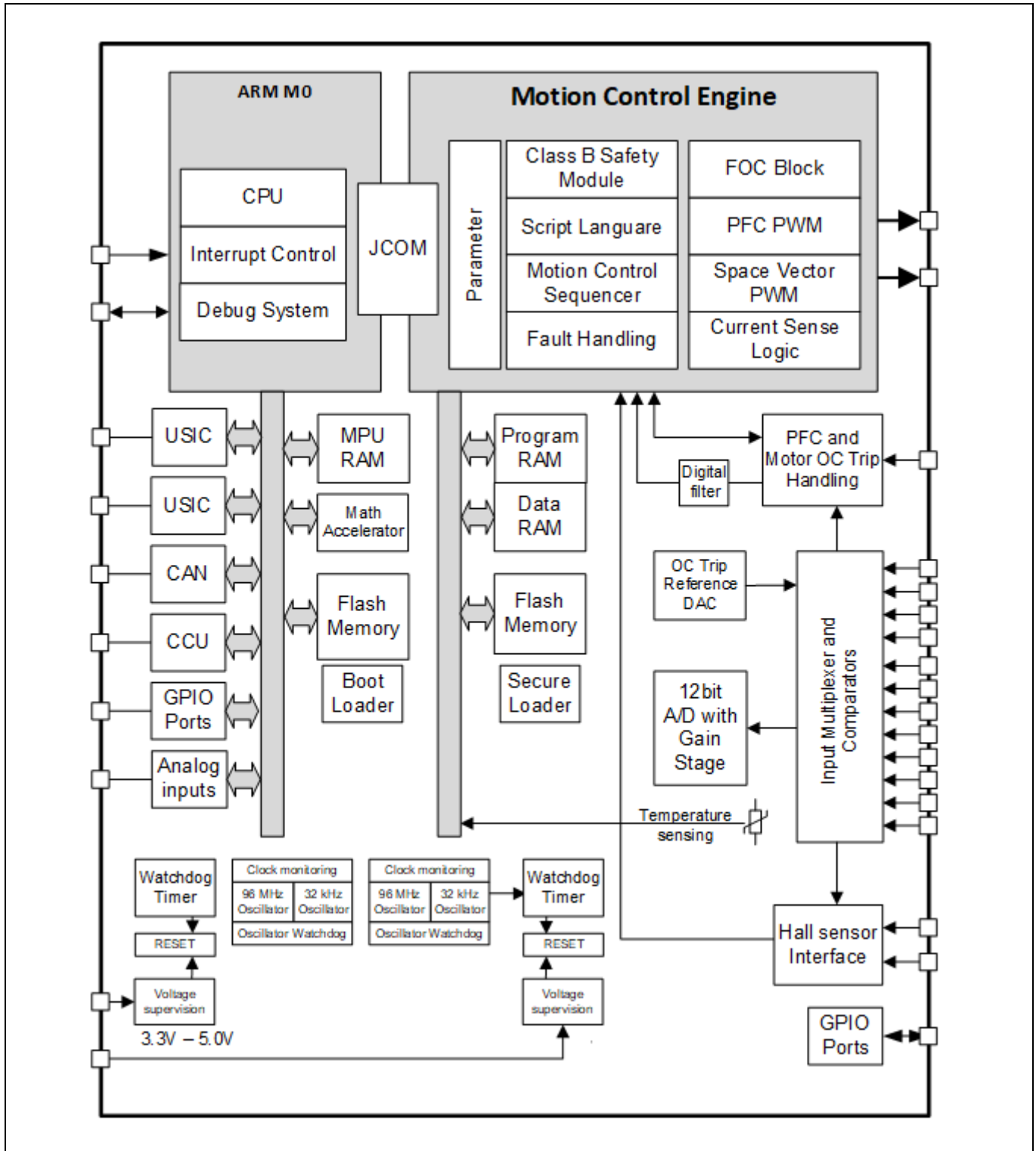


Figure 1 Block Diagram

**Pin Configuration**

## 2 Pin Configuration

The following tables give the pin configurations of the individual devices of the IMC300 series in the available packages.

The pin type is specified as follows:

- P – power and ground pins
- I - digital input
- O - digital output
- IO – digital input or output
- AIN - analog input
- AO – analog output

Each of the IMC300 cores has control over a different set of pins. The MCE core pins are labeled by system function which can be a single fixed function or multiple function options that are selected according to the MCE software configuration. The MCE functions and configuration options are described in the MCE Software reference manual.

The User Application core pins are labeled by port number (Pn.m) and have peripheral I/O functions selected according to the user software. The peripheral I/O function selection and configuration options are described in the IMC300 hardware reference manual.

Pins that do not have any signal assigned are reserved for future use. These pins should be left unconnected and neither be connected to ground nor to the positive supply.

*Note: The reference voltage for motor current trip protection is generated by an internal DAC, therefore pins like REFU, REFV, and REFW only require a blocking capacitor.*

### 2.1 Pin Configuration IMC301A/IMC302A

Signal	Type	IMC301A-F064	IMC301A-F048	IMC302A-F064	IMC302A-F048	Description
Supply Pins						
VDD	P	24,25,35,50	21,28,38	24,25,35,50	21,28,38	Supply Voltage
VSS	P	23,49	20,37	23,49	20,37	Ground
Motor control						
PWMUL	O	29	22	29	22	PWM output phase U low
PWMUH	O	30	23	30	23	PWM output phase U high
PWMVL	O	31	24	31	24	PWM output phase V low
PWMVH	O	32	25	32	25	PWM output phase V high
PWMWL	O	33	26	33	26	PWM output phase W low
PWMWH	O	34	27	34	27	PWM output phase W high
GK	I	36	29	36	29	Motor gate kill input
VDC	AIN	14	11	14	11	DC bus sensing input



**Pin Configuration**

IU/ISS	AIN	18	15	18	15	Current sense input phase U / single shunt
IV	AIN	15	12	15	12	Current sense input phase V
IW	AIN	11	8	11	8	Current sense input phase W
REFU	AO	17	14	17	14	Itrip phase U reference output
REFV	AIN	16	13	16	13	Itrip phase V reference
REFW	AIN	10	7	10	7	Itrip phase W reference

Hall sensor inputs

AHALL1+	AIN	10	7	10	7	analog Hall sensor Input1+
AHALL1-	AIN	11	8	11	8	analog Hall sensor input 1-
AHALL2+	AIN	16	13	16	13	analog Hall sensor input 2+
AHALL2-	AIN	15	12	15	12	analog Hall sensor input 2-
HALL1	IO	26	-	26	-	Digital Hall sensor input 1
HALL2	IO	27	-	27	-	Digital Hall sensor input 2
HALL3	IO	28	-	28	-	Digital Hall sensor input 3

Power Factor Correction

PFCG0	O	-	-	44	33	PFC gate drive 0
PFCG1	O	-	-	43	32	PFC gate drive 1 (totem pole PFC)
IPFC	AIN	-	-	12	9	PFC current sensing
IPFCREF	AIN	-	-	21	18	PFC Itrip reference
IPFCTRIP	AIN	-	-	22	19	PFC Trip
VAC1	AIN	-	-	20	17	AC voltage sensing input 1
VAC2	AIN	-	-	19	16	AC voltage sensing input 2

Interface

PGOUT	O	42	31	42	31	Pulse output
NTC/ AIN4	AIN	13	10	13	10	External thermistor input /analog input
LED	O	41	30	41	30	Status LED

Communication

RXD0	I	45	35	45	35	UART0 reception for SW download
TXD0	O	46	36	46	36	UART0 transmission for SW download

Scripting

AIN1	AIN	10	7	10	7	Analog input
AIN2	AIN	11	8	11	8	Analog input
AIN3	AIN	12	9	-	-	Analog input
AIN4	AIN	13	10	13	10	Analog input
AIN7	AIN	16	13	16	13	Analog input
AIN10	AIN	19	16	-	-	Analog input
AIN11	AIN	20	17	-	-	Analog input
GPIO2	IO	-	32	-	-	User configurable I/O, digital

**Pin Configuration**

GPIO3	IO	-	33	-	-	User configurable I/O, digital
GPIO4	IO	-	34	-	34	User configurable I/O, digital
GPIO5	IO	-	18	-	-	User configurable I/O, digital
GPIO6	IO	-	19	-	-	User configurable I/O, digital
GPIO7	IO	21	-	-	-	User configurable I/O, digital
GPIO8	IO	22	-	-	-	User configurable I/O, digital
GPIO9	IO	26	-	26	-	User configurable I/O, digital
GPIO10	IO	27	-	27	-	User configurable I/O, digital
GPIO11	IO	28	-	28	-	User configurable I/O, digital
GPIO12	IO	37	-	37	-	User configurable I/O, digital
GPIO13	IO	38	-	38	-	User configurable I/O, digital
GPIO14	IO	39	-	39	-	User configurable I/O, digital
GPIO15	IO	40	-	40	-	User configurable I/O, digital
GPIO16	IO	43	-	-	-	User configurable I/O, digital
GPIO17	IO	44	-	-	-	User configurable I/O, digital

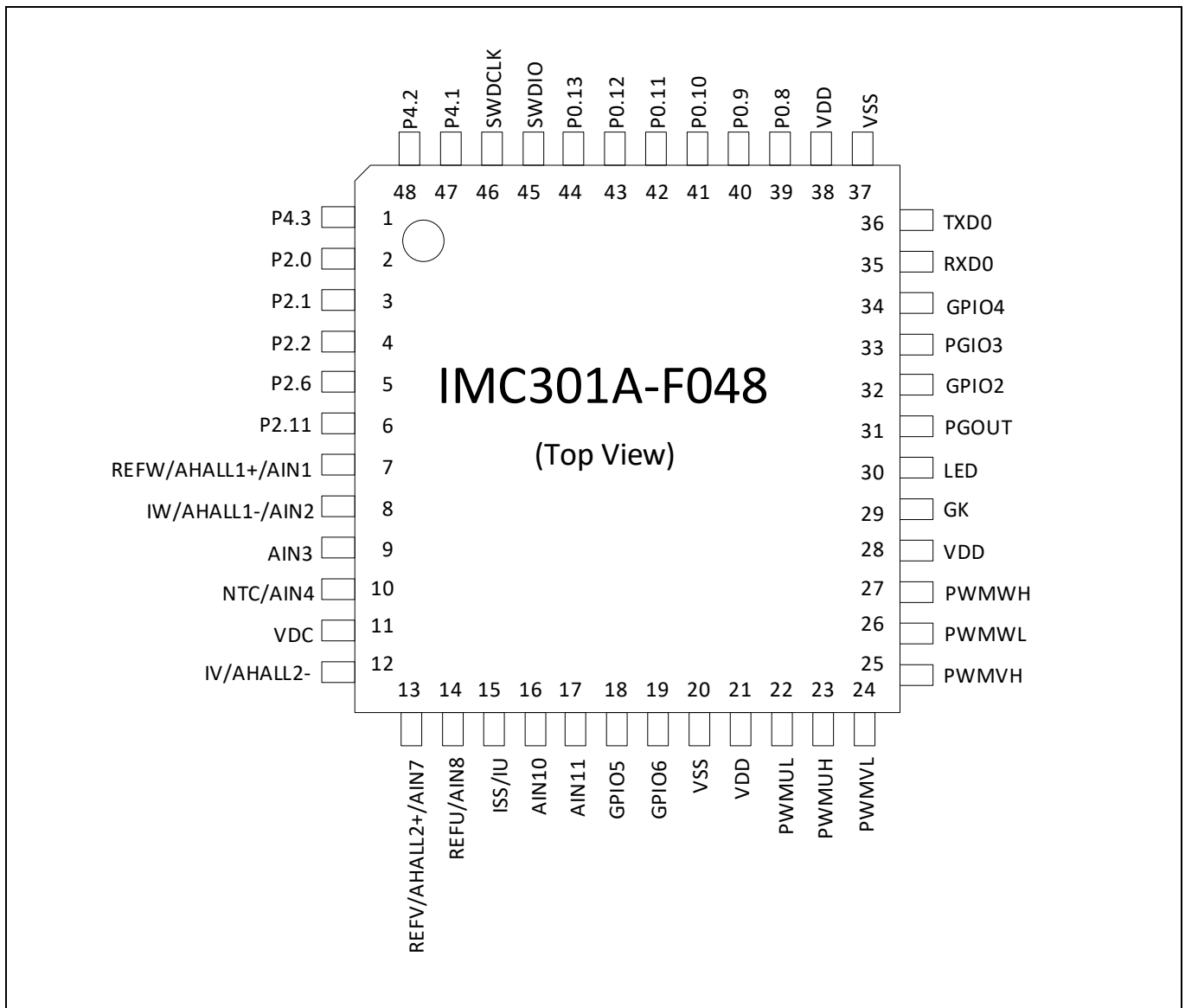
Microcontroller

P0.8	IO	51	39	51	39	Programmable I/O
P0.9	IO	52	40	52	40	Programmable I/O
P0.10	IO	53	41	53	41	Programmable I/O
P0.11	IO	54	42	54	42	Programmable I/O
P0.12	IO	55	43	55	43	Programmable I/O
P0.13	IO	56	44	56	44	Programmable I/O
P0.14/ SWDIO	IO	57	45	57	45	Programmable I/O / User serial debug I/O
P0.15/ SWDCLK	I	58	46	58	46	Programmable I/O / User serial debug clock
P1.0	IO	48	-	48	-	Programmable I/O
P1.1	IO	47	-	47	-	Programmable I/O
P2.0/ (TXD2_A)	IO/ AIN	3	2	3	2	Programmable I/O / UART2 transmission / analog input
P2.1/ (RXD2_A)	IO/ AIN	4	3	4	3	Programmable I/O / UART2 reception/ analog input
P2.2	IO/AIN	5	4	5	4	Programmable I/O or analog input
P2.6	IO/AIN	6	5	6	5	Programmable I/O or analog input
P2.8	IO/AIN	7	-	7	-	Programmable I/O or analog input
P2.10	IO/AIN	8	-	8	-	Programmable I/O or analog input
P2.11	IO/AIN	9	6	9	6	Programmable I/O or analog input
P4.0	IO	59	-	59	-	Programmable I/O
P4.1	IO	60	47	60	47	Programmable I/O
P4.2	IO	61	48	61	48	Programmable I/O

**Pin Configuration**

P4.3	IO	62	1	62	1	Programmable I/O
P4.4/ (RXD1_A)	I	63	-	63	-	Programmable I/O / UART1 transmission /
P4.5/ (TXD1_A)	O	64	-	64	-	Programmable I/O / UART1 reception
P4.6	IO	1	-	1	-	Programmable I/O
P4.7	IO	2	-	2	-	Programmable I/O

**2.2 Pin Configuration Drawing IMC301A**



**Figure 2 IMC301-F048**

Pin Configuration

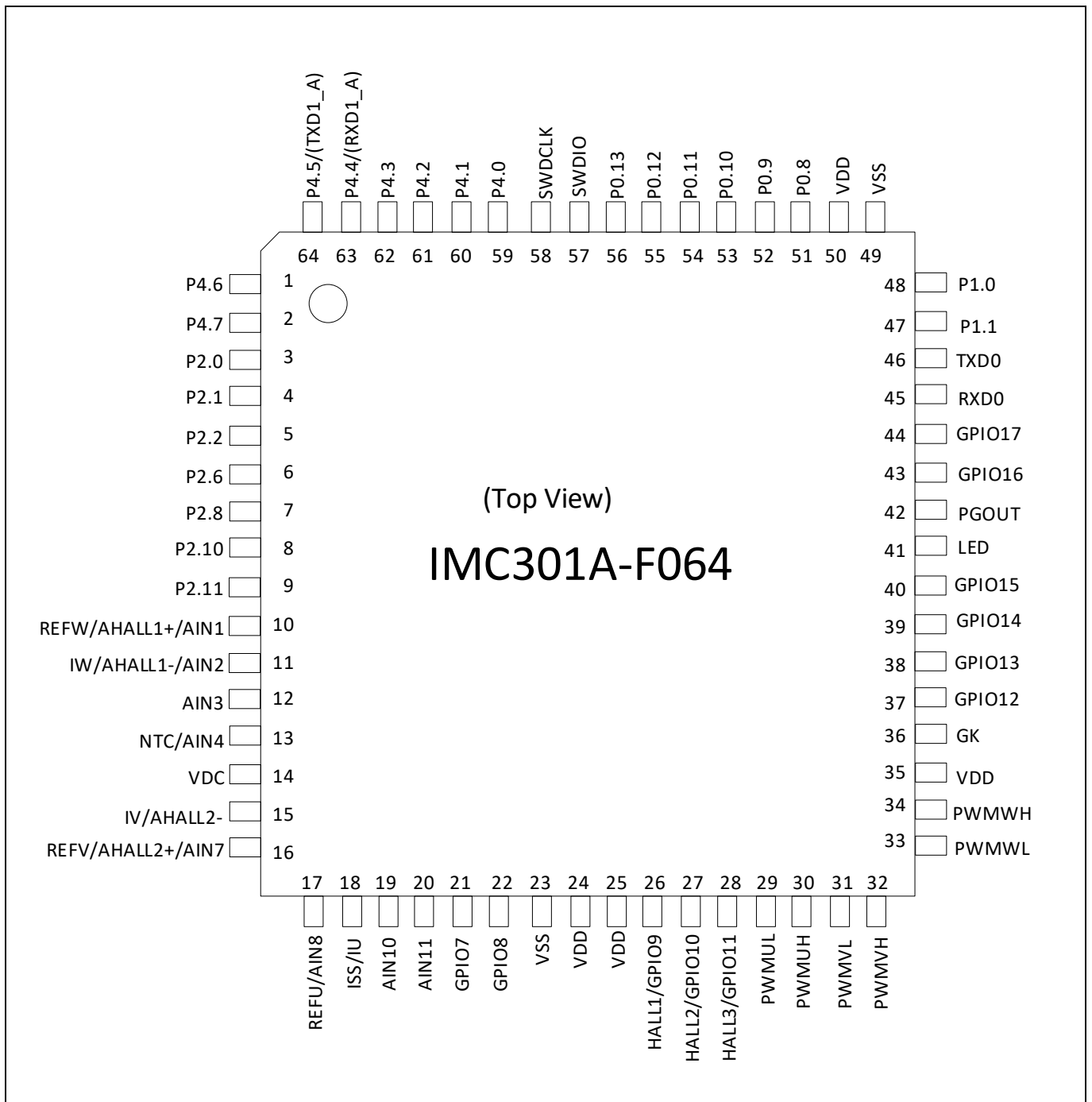


Figure 3 IMC301A-F064

Note: The recommended alternative pin assignment functions are within the parenthesis symbol ().

Pin Configuration

2.3 Pin Configuration Drawing IMC302A

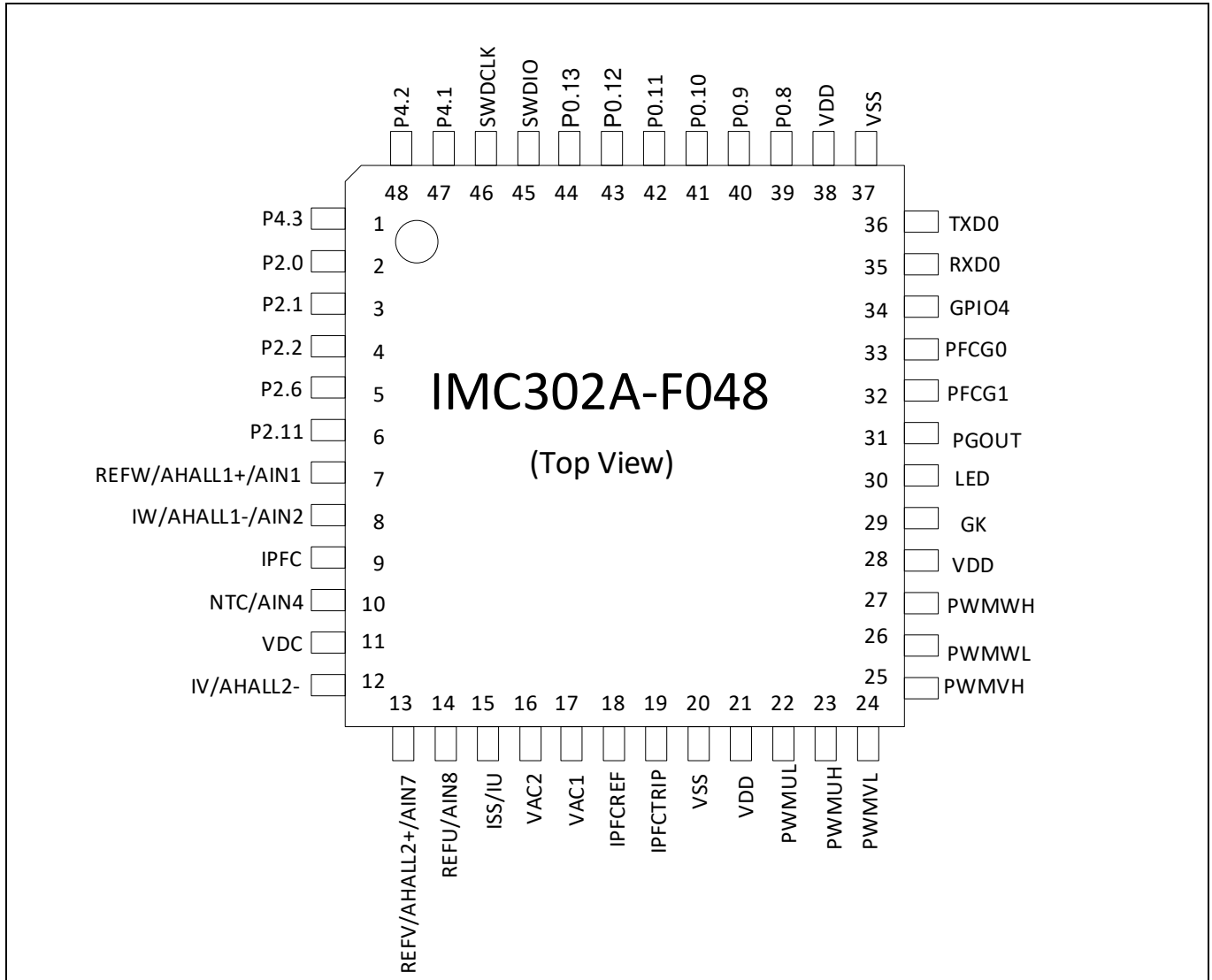
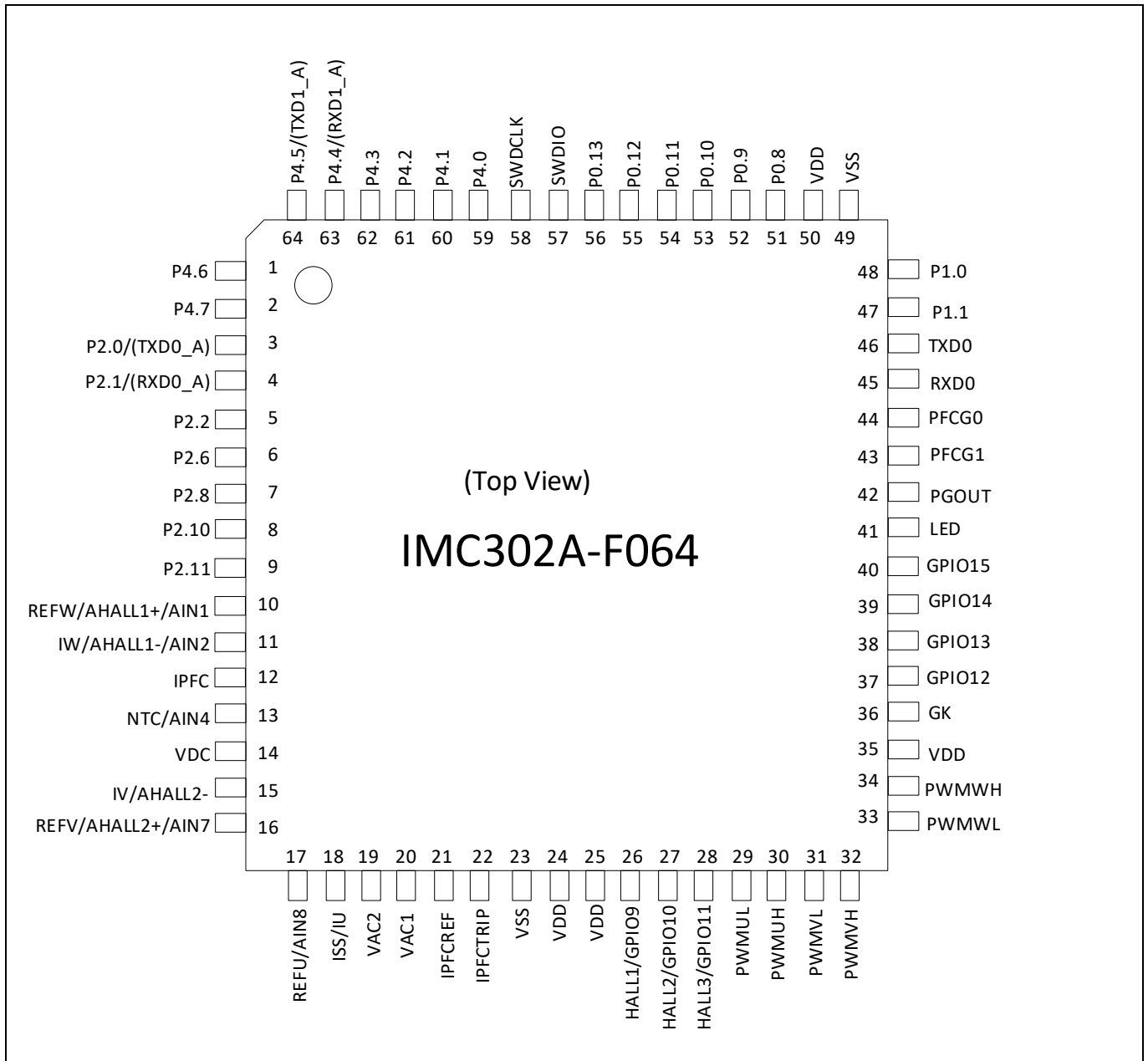


Figure 4 IMC302A-F048

Pin Configuration



**Figure 5** IMC302A-F064

Note: The recommended alternative pin assignment functions are within the parenthesis symbol ().

Functional Description

### 3 Functional Description

The IMC300 architecture is based on the combination of the Motion Control Engine (MCE) for sensored/sensorless motor control and PFC regulation and an additional microcontroller (MCU) based on an Arm® Cortex®-M0 core.

The MCE contains an embedded motor control algorithm with fast angle sensing at startup and enables low and ultra-high speed operation, and offers either single shunt current sensing or leg shunt current sensing. PFC control supports two topologies, namely a single stage boost mode PFC and a totem-pole PFC with 50 kHz fast switching application to minimize the inductor size. User can configure the motor and PFC parameters for each specific motors and store into the onboard Flash memory. The MCE also contains the UL 607310-1 Software Safety certified library and modules.

The MCU is based on an Arm® Cortex®-M0 core and provides 128 Kbyte of flash and 16 Kbyte of RAM memory. The peripheral set is targeting communication and system application tasks.

Both units – MCE and MCU – run largely independantly up to the fact that the MCU can be debugged while the motor is still running. Communication between the two units is using a fast serial interface called JCOM.

#### 3.1 Application Connection for IMC301A with Single Shunt Current Sensing

The following figure shows the application connection for a single motor configuration. This example is based on a single shunt resistor current sensing configuration.

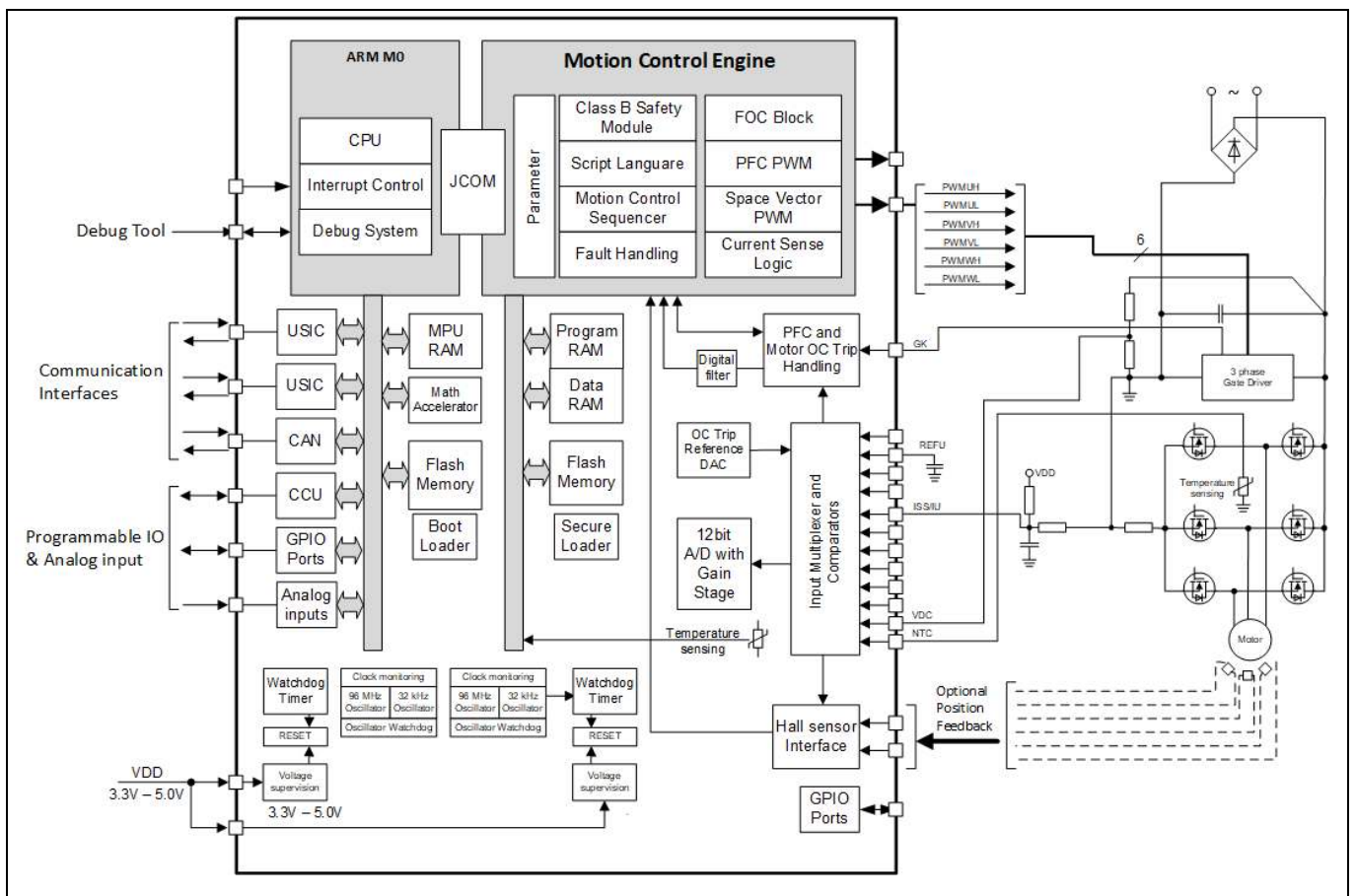


Figure 6 IMC301A Application Connection

Functional Description

3.2 Application Connection for IMC302A with Single Shunt Current Sensing

The following figure shows the application connection for an air conditioner outdoor unit configuration with single shunt current sensing and a boost mode PFC configuration. Hall sensor feedback options support applications requiring high starting torque.

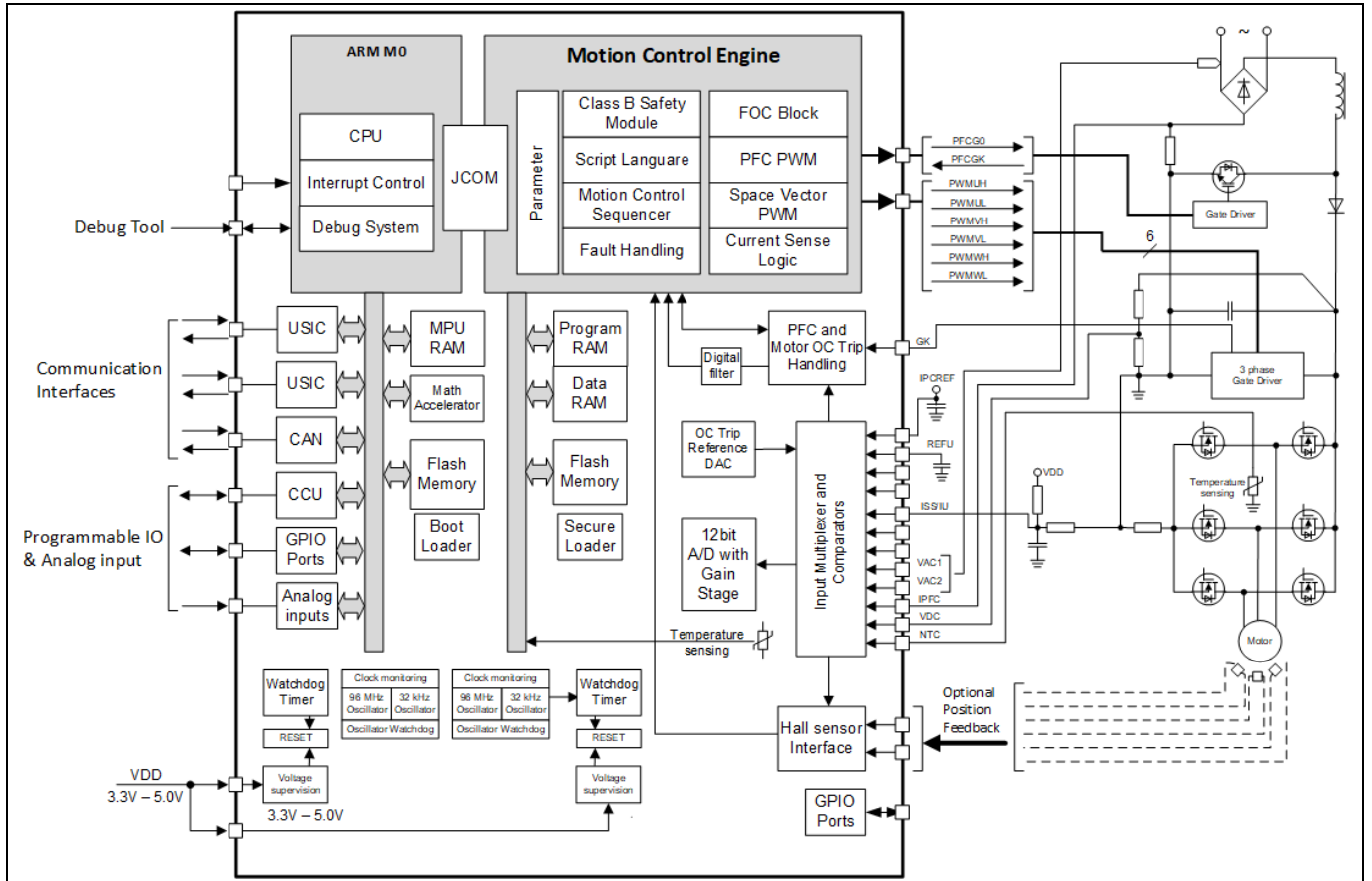


Figure 7 IMC302A Application Connection (Single Shunt Current Sensing)



Functional Description

### 3.3 Application Connection for IMC302A with Leg Shunt Current Sensing

The following figure shows the application connection for an air conditioner outdoor unit configuration with leg shunt current sensing and a boost mode PFC configuration.

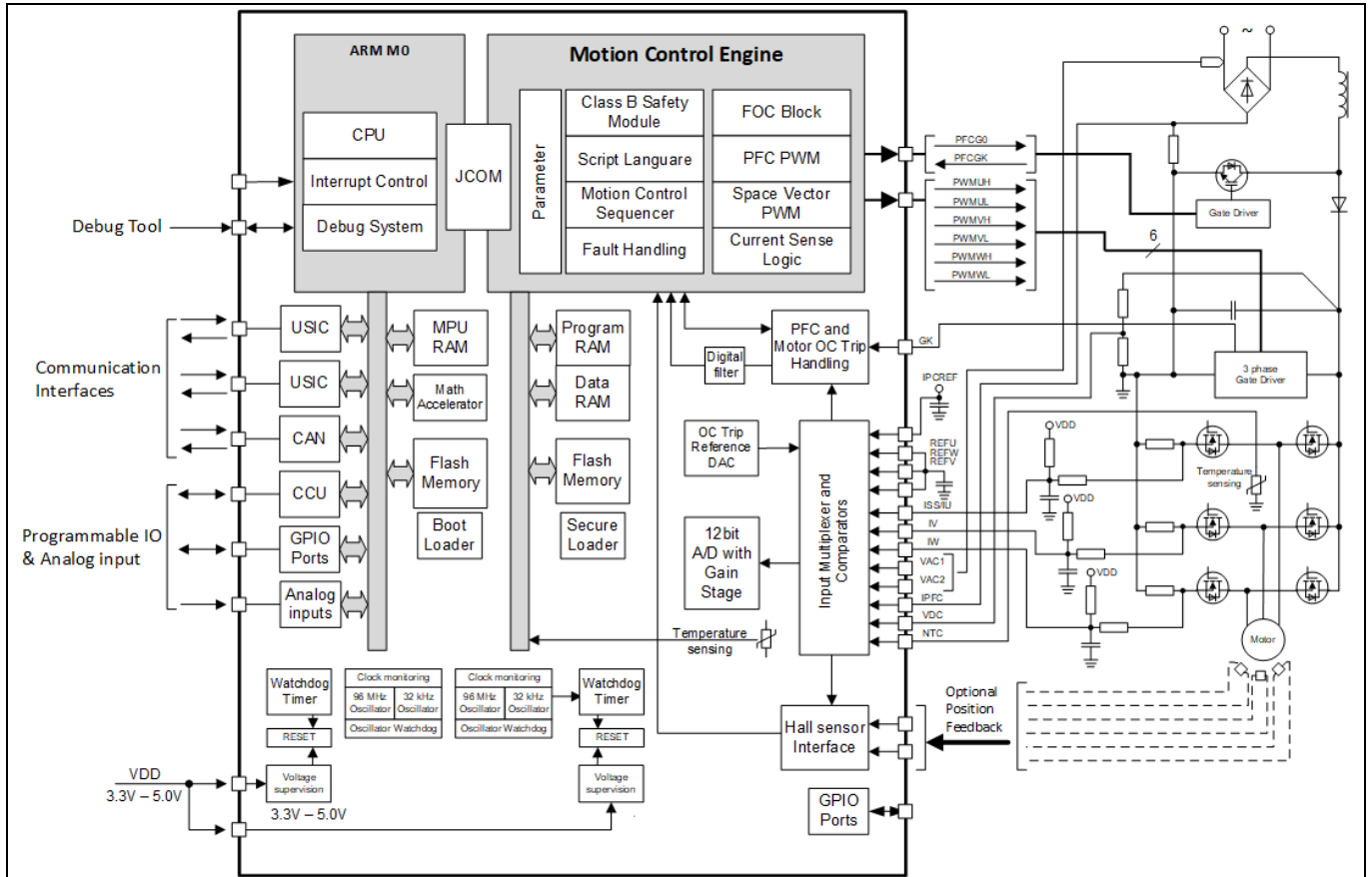


Figure 8 IMC302A Application Connection (Leg Shunt Current Sensing)

## Electrical characteristics and parameters

# 4 Electrical characteristics and parameters

## 4.1 General Parameters

### 4.1.1 Parameter Interpretation

The parameters listed in this section represent partly the characteristics of the IMC300 and partly its requirements on the system. To aid interpreting the parameters easily when evaluating them for a design, they are indicated by the abbreviations in the “Symbol” column:

- **CC**  
Such parameters indicate **C**ontroller **C**haracteristics, which are distinctive feature of the IMC300 and must be regarded for a system design.
- **SR**  
Such parameters indicate **S**ystem **R**equirements, which must be provided by the application system in which the IMC300 is designed in.

### 4.1.2 Absolute Maximum Ratings

Stresses above the values listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

**Table 3 Absolute Maximum Rating Parameters**

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Ambient temperature	$T_A$ SR	-40	–	105	°C	–
Junction temperature	$T_J$ SR	-40	–	115	°C	–
Storage temperature	$T_{ST}$ SR	-40	–	125	°C	–
Voltage on power supply pin with respect to $V_{SS}$	$V_{DD}$ SR	-0.3	–	6	V	–
Voltage on pins with respect to $V_{SS}$	$V_{IN}$ SR	-0.3	–	$V_{DDP} + 0.3$	V	–
Input current on any pin during overload condition	$I_{IN}$ SR	-5	–	5	mA	–
Absolute maximum sum of all input currents during overload condition	$\Sigma I_{IN}$ SR		–	25	mA	–

**Electrical characteristics and parameters**

**4.1.3 Pin Reliability in Overload**

When receiving signals from higher voltage devices, low-voltage devices experience overload currents and voltages that go beyond their own IO power supplies specification.

**Table 4** defines overload conditions that will not cause any negative reliability impact if all the following conditions are met:

- full operation life-time is not exceeded
- **Operating Conditions** are met for
  - pad supply levels ( $V_{DDP}$ )
  - temperature

If a pin current is outside of the **Operating Conditions** but within the overload conditions, then the parameters of this pin as stated in the Operating Conditions can no longer be guaranteed. Operation is still possible in most cases but with relaxed parameters.

*Note:* An overload condition on one or more pins does not require a reset.

*Note:* A series resistor at the pin to limit the current to the maximum permitted overload current is sufficient to handle failure situations like short to battery.

**Table 4 Overload Parameters**

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Input current on analog port pins during overload condition	$I_{OVA}$ SR	-3	–	3	mA	
Input current on any port pin during overload condition	$I_{OV}$ SR	-5	–	5	mA	
Absolute sum of all input circuit currents during overload condition	$I_{OVS}$ SR	–	–	25	mA	

**Figure 10** shows the path of the input currents during overload via the ESD protection structures. The diodes against  $V_{DDP}$  and ground are a simplified representation of these ESD protection structures.

Electrical characteristics and parameters

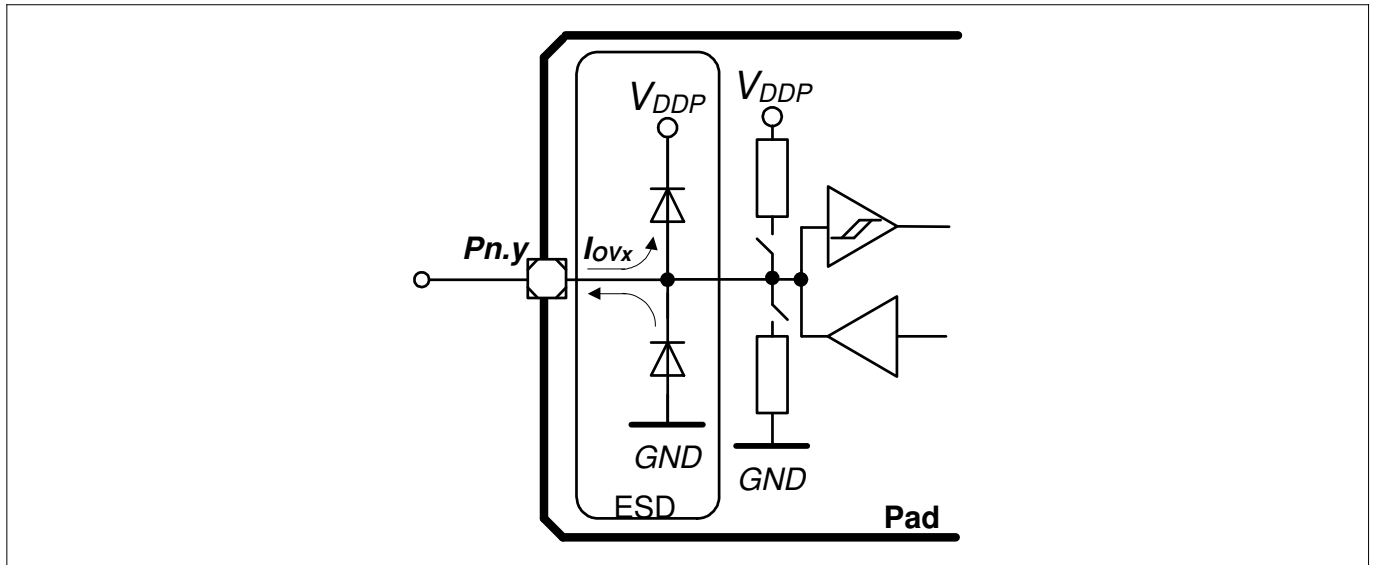


Figure 10 Input Overload Current via ESD structures

Table 5 and Table 6 list input voltages that can be reached under overload conditions. Note that the absolute maximum input voltages as defined in the Absolute Maximum Ratings must not be exceeded during overload.

Table 5 PN-Junction Characteristics for positive Overload

Pad Type	$I_{OV} = 5 \text{ mA}$
Standard, High-current, AN/DIG_IN	$V_{IN} = V_{DD} + (0.3 \dots 0.5) \text{ V}$ $V_{AIN} = V_{DD} + 0.5 \text{ V}$ $V_{AREF} = V_{DD} + 0.5 \text{ V}$

Table 6 PN-Junction Characteristics for negative Overload

Pad Type	$I_{OV} = 5 \text{ mA}$
Standard, High-current, AN/DIG_IN	$V_{IN} = V_{SS} - (0.3 \dots 0.5) \text{ V}$ $V_{AIN} = V_{SS} - 0.5 \text{ V}$ $V_{AREF} = V_{SS} - 0.5 \text{ V}$

## Electrical characteristics and parameters

### 4.1.4 Operating Conditions

The following operating conditions must not be exceeded in order to ensure correct operation and reliability of the IMC300. All parameters specified in the following tables refer to these operating conditions, unless noted otherwise.

**Table 7 Operating Conditions Parameters**

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Ambient Temperature	$T_A$ SR	-40	–	105	°C	
Junction temperature	$T_J$ SR	-40	–	115	°C	
Digital supply voltage <sup>1)</sup>	$V_{DDP}$ SR	3.0	3.3	5.5	V	All $V_{DD}$ pins need to be connected on the circuit board.
Short circuit current of digital outputs <sup>2)</sup>	$I_{SC}$ SR	-5	–	5	mA	
Absolute sum of short circuit currents of the device <sup>2)</sup>	$\Sigma I_{SC\_D}$ SR	–	–	25	mA	For MCE peripheral pins
Absolute sum of short circuit currents of the device <sup>3)</sup>	$\Sigma I_{SC\_D}$ SR	–	–	25	mA	For MCU peripheral pins

<sup>1)</sup> See also the Supply Monitoring thresholds [Power-Up and Supply Threshold Characteristics](#).

<sup>2)</sup> Applicable for digital outputs.

<sup>2)</sup> See also section "Pin Reliability in Overload" for overload current definitions.

<sup>3)</sup> See also section "Pin Reliability in Overload" for overload current definitions.

## Electrical characteristics and parameters

### 4.1.5 Input/Output Characteristics

The table below provides the characteristics of the input/output pins of the IMC300.

*Note:* These parameters are not subject to production test, but verified by design and/or characterization.

*Note:* Unless otherwise stated, input DC and AC characteristics, including peripheral timings, assume that the input pads operate with the standard hysteresis.

**Table 8 Input/Output Characteristics (Operating Conditions apply)**

Parameter	Symbol		Limit Values		Unit	Test Conditions
			Min.	Max.		
Output low voltage on port pins	VOLP	CC	–	1.0	V	$I_{OL} = 11 \text{ mA (5 V)}$ $I_{OL} = 7 \text{ mA (3.3 V)}$
			–	0.4	V	$I_{OL} = 5 \text{ mA (5 V)}$ $I_{OL} = 3.5 \text{ mA (3.3 V)}$
Output low voltage on PWM outputs	VOLP1	CC	–	1.0	V	$I_{OL} = 50 \text{ mA (5 V)}$ $I_{OL} = 25 \text{ mA (3.3 V)}$
			–	0.32	V	$I_{OL} = 10 \text{ mA (5 V)}$
			–	0.4	V	$I_{OL} = 5 \text{ mA (3.3 V)}$
Output high voltage on port pins	VOHP	CC	$V_{DDP} - 1.0$	–	V	$I_{OH} = -10 \text{ mA (5 V)}$ $I_{OH} = -7 \text{ mA (3.3 V)}$
			$V_{DDP} - 0.4$	–	V	$I_{OH} = -4.5 \text{ mA (5 V)}$ $I_{OH} = -2.5 \text{ mA (3.3 V)}$
Output high voltage on PWM outputs	VOHP1	CC	$V_{DDP} - 0.32$	–	V	$I_{OH} = -6 \text{ mA (5 V)}$
			$V_{DDP} - 1.0$	–	V	$I_{OH} = -8 \text{ mA (3.3 V)}$
			$V_{DDP} - 0.4$	–	V	$I_{OH} = -4 \text{ mA (3.3 V)}$
Rise/fall time on PWM outputs <sup>1)</sup>	$t_{HCPR}$ , $t_{HCPF}$	CC	–	9	ns	50 pF @ 5 V
			–	12	ns	50 pF @ 3.3 V
Rise/fall time on standard pad	$t_R$ , $t_F$	CC	–	12	ns	50 pF @ 5 V
			–	15	ns	50 pF @ 3.3 V.
Pin capacitance (digital inputs/outputs)	$C_{IO}$	CC	–	10	pF	

<sup>1</sup> Rise/Fall time parameters are taken with 10% - 90% of supply.

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**Electrical characteristics and parameters**
**Table 8 Input/Output Characteristics (Operating Conditions apply) (continued)**

Parameter	Symbol		Limit Values		Unit	Test Conditions
			Min.	Max.		
Pull-up/-down resistor on port pins (if enabled in software)	$R_{PUP}$	CC	20	50	k $\Omega$	$V_{IN} = V_{SSP}$
Input leakage current <sup>1)</sup>	$I_{OZP}$	CC	-1	1	$\mu$ A	$0 < V_{IN} < V_{DDP}$ , $T_A 105^\circ\text{C}$
Maximum current per pin standard pin	$I_{MP}$	SR	-10	11	mA	–
Maximum current per PWM outputs pins	$I_{MP1A}$	SR	-10	50	mA	–
Maximum current into $V_{DDP}$ / out of $V_{SS}$	$I_{MVDD}$ / $I_{MVSS}$	SR	–	260	mA	

---

<sup>1</sup> An additional error current ( $I_{INJ}$ ) will flow if an overload current flows through an adjacent pin.

## Electrical characteristics and parameters

### 4.1.6 Analog to Digital Converter (ADC)

The following table shows the Analog to Digital Converter (ADC) characteristics. This specification applies to all analog input as given in the pin configuration list.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

**Table 9 ADC Characteristics (Operating Conditions apply)<sup>1)</sup>**

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Supply voltage range	$V_{DD}$ SR	3.0	–	5.5	V	
Analog input voltage range	$V_{AIN}$ SR	$V_{SSP} - 0.05$	–	$V_{DDP} + 0.05$	V	
Conversion time	$t_{C12}$ CC	–	1.0	1.6	$\mu$ s	
Total capacitance of an analog input	$C_{AINT}$ CC	–	–	10	pF	
Total capacitance of the reference input	$C_{AREFT}$ CC	–	–	10	pF	
Sample time	$t_{sample}$ CC	–	200	–	ns	
RMS noise	$EN_{RMS}$ CC	–	1.5	–	LSB12	
DNL error	$EA_{DNL}$ CC	–	$\pm 2.0$	–	LSB12	
INL error	$EA_{INL}$ CC	–	$\pm 4.0$	–	LSB12	
Gain error	$EA_{GAIN}$ CC	–	$\pm 0.5$	–	%	$V_{DD} = 3.3V$
Offset error	$EA_{OFF}$ CC	–	$\pm 8.0$	–	mV	

<sup>1)</sup> All parameters are defined for the full supply range if not stated otherwise.



**Electrical characteristics and parameters**

**4.1.7 Power Supply Current**

The total power supply current defined below consists of a leakage and a switching component. Application relevant values are typically lower than those given in the following tables, and depend on the customer's system operating conditions (e.g. thermal connection or used application configurations).

*Note: These parameters are not subject to production test, but verified by design and/or characterization.*

**Table 10 Power Supply parameter table;  $V_{DDP} = 5V$**

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Active mode current motor control only	$I_{DDPWM}$ CC	–	15	40	mA	MCE clock 48MHz MPU clock 1 – 48Mhz
Active mode current motor control plus PFC	$I_{DDPFC}$ CC	–	19	40	mA	IMC302A only
Deep Sleep mode current <sup>1)</sup>	$I_{DDPDS}$ CC	–	0.54	–	mA	Both cores
Wake-up time from Sleep to Active mode	$t_{SSA}$ CC	–	6	–	cycles	
Wake-up time from Deep Sleep to Active mode	$t_{DSA}$ CC	–	290	–	µsec	

**4.1.8 Flash Memory Parameters**

*Note: These parameters are not subject to production test, but verified by design and/or characterization.*

**Table 11 Flash Memory Parameters**

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Data Retention Time	$t_{RET}$ CC	10			years	Max. 100 erase / program cycles
Erase Cycles <sup>2)</sup>	$N_{ECYC}$ CC			$5 \cdot 10^4$	cycles	Sum of page and sector erase cycles
Total Erase Cycles	$N_{TECYC}$ CC			$2 \cdot 10^6$	cycles	

<sup>1</sup> CPU in sleep, peripherals clock disabled, Flash is powered down and code executed from RAM after wakeup.

<sup>2</sup> Sum of page erase and sector erase cycles a page sees.

Electrical characteristics and parameters

4.2 AC Parameters

4.2.1 Testing Waveforms

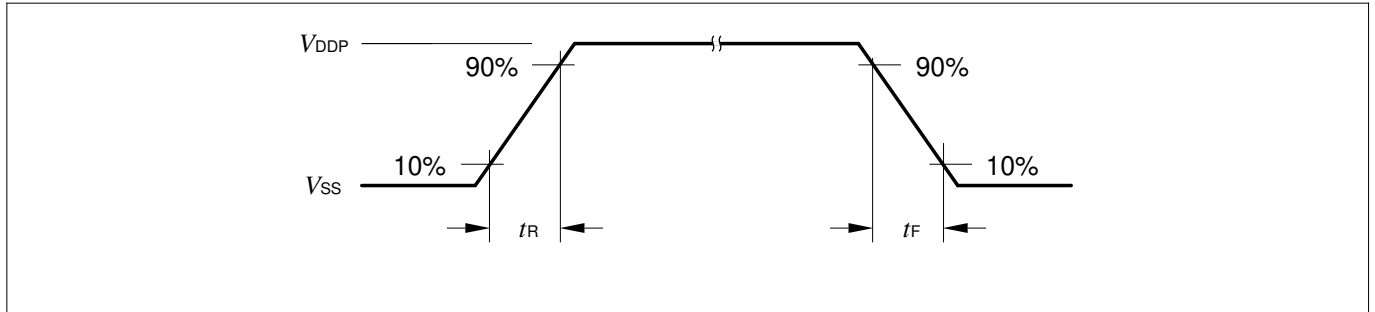


Figure 11 Rise/Fall Time Parameters

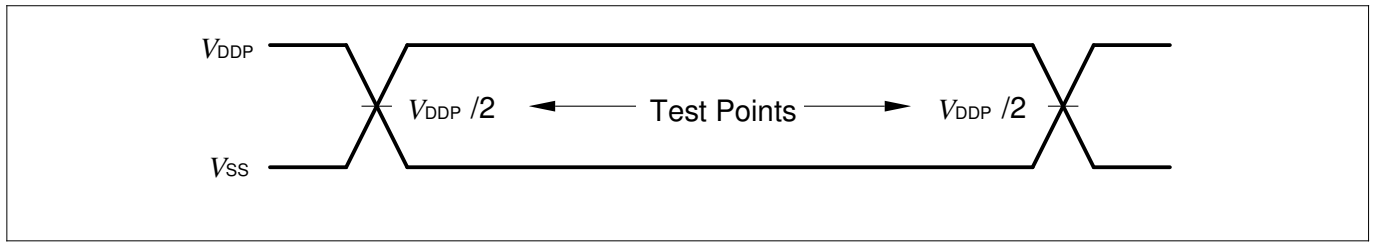


Figure 12 Testing Waveform, Output Delay

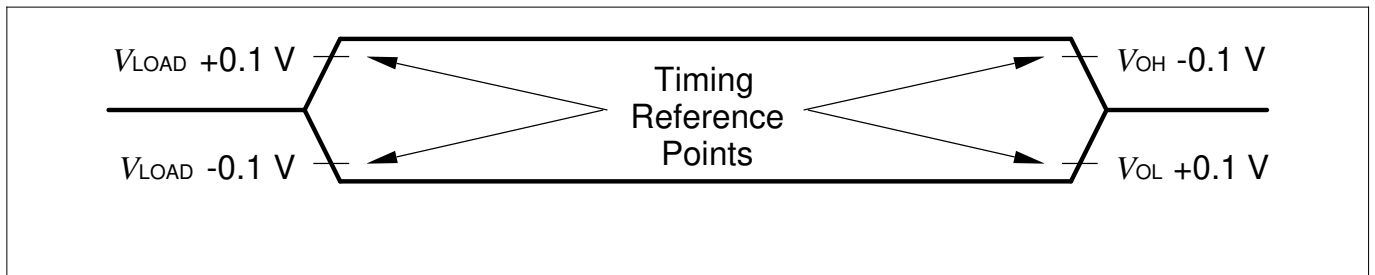


Figure 13 Testing Waveform, Output High Impedance

**Electrical characteristics and parameters**

**4.2.2 Power-Up and Supply Threshold Characteristics**

This chapter provides the characteristics of the supply threshold in IMC300.

The guard band between the lowest valid operating voltage and the brownout reset threshold provides a margin for noise immunity and hysteresis. The electrical parameters may be violated while  $V_{DDP}$  is outside its operating range.

The brownout detection triggers a reset within the defined range. The prewarning detection can be used to trigger an early warning and issue corrective and/or fail-safe actions in case of a critical supply voltage drop.

*Note: These parameters are not subject to production test, but verified by design and/or characterization.*

*Note: Operating Conditions apply.*

**Table 12 Power-Up and Supply Threshold Parameters**

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
$V_{DDP}$ ramp-up time	$t_{RAMPUP}$ SR	$V_{DDP}/SV_{DDP}rise$	–	$10^7$	$\mu s$	
$V_{DDP}$ slew rate	$SV_{DDPOP}$ SR	0	–	0.1	$V/\mu s$	Slope during normal operation
	$SV_{DDP10}$ SR	0	–	10	$V/\mu s$	Slope during fast transient within +/-10% of $V_{DDP}$
	$SV_{DDPrise}$ SR	0	–	10	$V/\mu s$	Slope during power-on or restart after brownout event
	$SV_{DDPfall}^{9)}$ SR	0	–	0.25	$V/\mu s$	Slope during supply falling out of the +/-10% limits <sup>10)</sup>
$V_{DDP}$ prewarning voltage	$V_{DDPPW}$ CC	2.1	2.25	2.4	V	ANAVDEL.VDEL_SELECT = 00 <sub>B</sub>
		2.85	3	3.15	V	ANAVDEL.VDEL_SELECT = 01 <sub>B</sub>
		4.2	4.4	4.6	V	ANAVDEL.VDEL_SELECT = 10 <sub>B</sub>

<sup>9</sup> A capacitor of at least 100 nF has to be added between  $V_{DDP}$  and  $V_{SSP}$  to fulfill the requirement as stated for this parameter.

<sup>10</sup> Valid for a 100 nF buffer capacitor connected to supply pin where current from capacitor is forwarded only to the chip. A larger capacitor value has to be chosen if the power source sink a current.

Electrical characteristics and parameters

**Table 12 Power-Up and Supply Threshold Parameters (continued)**

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
$V_{DDP}$ brownout reset voltage	$V_{DDPBO}$ CC	1.55	1.62	1.75	V	calibrated, before user code starts running
$V_{DDP}$ voltage to ensure defined pad states	$V_{DDPPA}$ CC	–	1.0	–	V	
Start-up time from poweron reset	$t_{SSW}$ CC	–	260	–	$\mu$ s	Time to the first user code instruction <sup>1)</sup>
Start-up time to PWM on	$t_{PWMON}$ CC	5.2	-	360	ms	Time to PWM enabled



**Figure 14 Supply Threshold Parameters**

<sup>1</sup> This values does not include the ramp-up time. During startup firmware execution, MCLK is running at 48 MHz and the clocks to peripheral as specified in register CGATSTAT0 are gated.

**Electrical characteristics and parameters**

**4.2.3 On-Chip Oscillator Characteristics**

**Table 13** provides the characteristics of the 96 MHz digital controlled oscillator DCO1. The DCO1 is used as the time base during normal operation. The MCE core always runs at 48 MHz. The MCU core starts up at 48MHz but can be reduced to 32MHz, 16MHz or 1 MHz after startup.

*Note:* These parameters are not subject to production test, but verified by design and/or characterization.

**Table 13 96 MHz DCO1 Characteristics**

Parameter	Symbol	Limit Values			Unit	Test Conditions
		Min.	Typ.	Max.		
Nominal frequency	$f_{NOM\ CC}$	95.7	96	96.3	MHz	under nominal conditions <sup>1)</sup> after trimming
Short term frequency deviation (over $V_{DDC}$ )	$\Delta f_{ST\ CC}$	-1	–	1	%	with respect to $f_{NOM}$ (typ), at 25°C
Accuracy	$\Delta f_{LT\ CC}$	-1.7	–	3.4	%	with respect to $f_{NOM}(typ)$ , over temperature (0°C to 85°C)
		-3.9	–	4.0	%	with respect to $f_{NOM}(typ)$ , over temperature (-40°C to 105°C)

**Table 14** provides the characteristics of the 32 kHz digital controlled oscillator DCO2. The DCO2 is only used internally as a secondary clock source for the internal watchdog and as a fallback in case of failure of DCO1.

**Table 14 32 kHz DCO2 Characteristics**

Parameter	Symbol	Limit Values			Unit	Test Conditions
		Min.	Typ.	Max.		
Nominal frequency	$f_{NOM\ CC}$	32.5	32.75	33	kHz	under nominal conditions <sup>2)</sup> after trimming
Short term frequency deviation (over $V_{DDC}$ )	$\Delta f_{ST\ CC}$	-1	–	1	%	with respect to $f_{NOM}(typ)$ , at 25°C
Accuracy	$\Delta f_{LT\ CC}$	-1.7	–	3.4	%	with respect to $f_{NOM}(typ)$ , over temperature (0°C to 85°C)
		-3.9	–	4.0	%	with respect to $f_{NOM}(typ)$ , over temperature (-40°C to 105°C)

<sup>1</sup> The deviation is relative to the factory trimmed frequency at nominal  $V_{DDC}$  and  $T_A = + 25^\circ C$ .

<sup>2</sup> The deviation is relative to the factory trimmed frequency at nominal  $V_{DDC}$  and  $T_A = + 25^\circ C$ .

**Electrical characteristics and parameters**

**4.3 Motor Control Parameters**

The following parameters are defined in the iMOTION™ Motion Control Engine (MCE) software.

**4.3.1 PWM Characteristics**

**Table 1 PWM carrier frequency Characteristics**

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
Motor PWM frequency	$f_{PWM}$	5	16	20	kHz	Ta=25C, VDD= nominal

**4.3.2 Current Sensing Characteristics**

**Table 2 Motor current sensing Characteristics**

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
Input range	$I_{PWM}$	VSS-0.05	-	VDD+0.05	V	Ta=25C, VDD=nominal
Configurable analog gain			1/3/6/12			
Itrip input range	$I_{PWMTRIP}$	VSS-0.05	-	VDD+0.05	V	
Itrip offset Accuracyy			±8	-	mV	
REF Input capacitance	$C_{REFIU/V/W}$	-	-	10	pF	External capacitance required on REFU,REFV, REFW

Electrical characteristics and parameters

4.3.3 Fault Timing

Table 3 Gatekill timing

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
GK pulse width	$I_{P_{PWM}}$	1	-	-	$\mu s$	$T_a=25C, V_{DD}=\text{nominal}$
GK input to PWM shutoff		-	1.3	-	$\mu s$	
Motor Fault reset timing	$t_{RESET}$	-	1.84	-	ms	Fault reset command via UART to PWM reactivation
Itrip to PWM shutoff	$t_{P_{WMOFF}}$	-	1.0	-	$\mu s$	Single shunt configuration
Itrip to PWM shutoff	$t_{P_{WMOFF}}$	-	1.0	-	$\mu s$	Leg shunt configuration

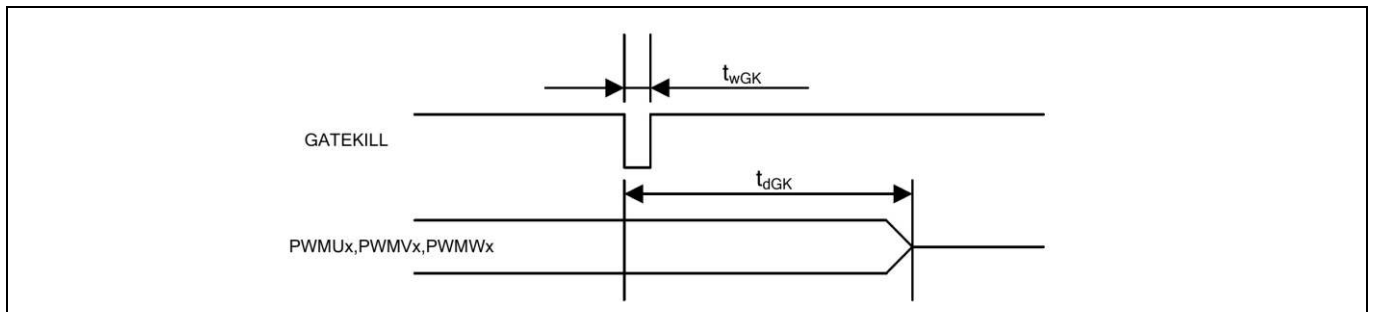


Figure 9 Fault timing

4.3.4 Analog Hall Sensing Characteristics

Table 4 Analog Hall input Characteristics

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
Input range	$V_H$	$V_{SS}-0.05$	-	$V_{DD}+0.05$	V	$T_a=25C, V_{DD}=\text{nominal}$
Comparator Offset	$V_{CMPOFF}$	-	$\pm 3$	-	mV	
Comparator Hysteresis			$\pm 15$	-	mV	

**Electrical characteristics and parameters**

**4.4 Power Factor Correction (PFC) parameters**

The following parameters are defined in the iMOTION™ Motion Control Engine (MCE) software.

**4.4.1 Boost PFC characteristics**

**Table 5 PWM carrier frequency Characteristics**

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
PFC PWM frequency	$f_{PWM}$	-	20	50	kHz	Motor PWM frequency within specified range

**4.4.2 Totem Pole PFC characteristics**

**Table 6 PWM carrier frequency Characteristics**

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
PFC PWM frequency	$f_{PWM}$	-	20	50	kHz	Motor PWM frequency within specified range

**4.4.3 PFC current sensing characteristics**

**Table 7 PFC current sensing Characteristics**

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
Input range	$I_{PFC}$	VSS-0.05	-	VDD+0.05	V	Ta=25C, VDD=nominal
Configurable analog gain			1/3/6/12			
Itrip input range	$I_{PFC\_TRIP}$	VSS-0.05	-	VDD+0.05	V	
Itrip offset			±3	-	mV	Input voltage difference > 200mV
REF Input capacitance	$C_{REFIPFC}$	-	-	10	pF	External capacitor required on IPFCREF

**4.4.4 PFC Fault timing**

**Table 8 PFC Fault timing**

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
Itrip to PFCPWM shutoff	$t_{PFCOFF}$	-	1.18	-	µs	
Motor Fault reset timing	$t_{RESET}$	-	1.0	-	ms	Fault reset command via UART to PWM reactivation



**Electrical characteristics and parameters**

**4.5 Control Interface Parameters (MCE)**

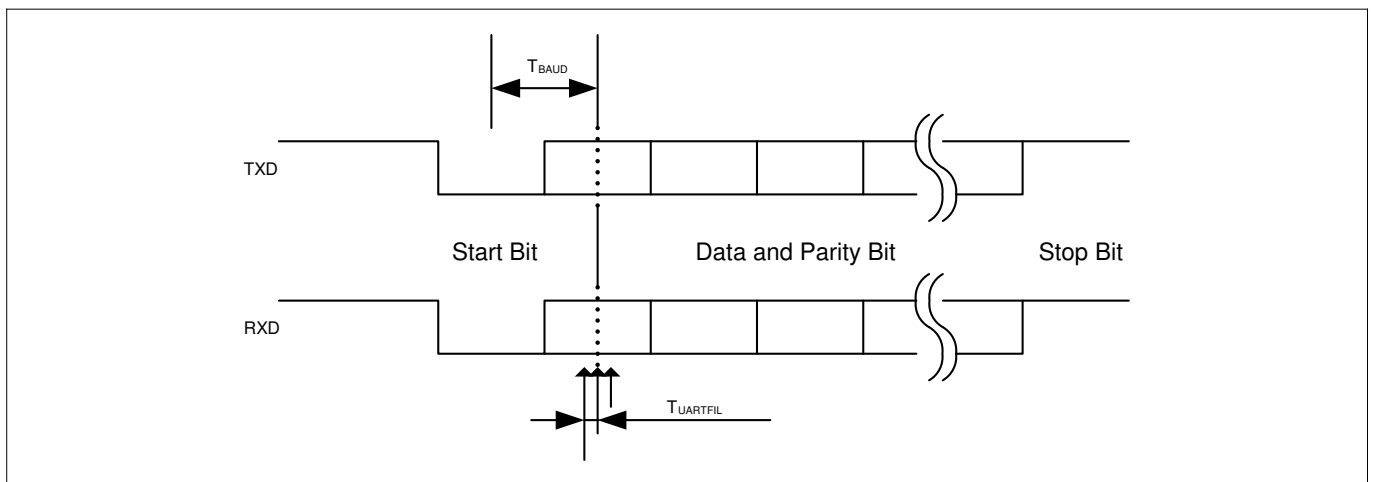
IMC300 series provides the following communication interfaces.

*Note: These parameters are not subject to production test, but verified by design and/or characterization.*

**4.5.1 UART Interface**

**Table 9 Electrical Characteristics**

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
UART baud rate		1200	57600	-	BPS	
UART mode		-	8-N-1	-		Data-parity-stop bit
UART sampling filter period	$T_{UARTFIL}$	-	1/16	-	$T_{BAUD}$	



**Figure 10 UART timing**

**4.5.2 Over Temperature Input**

The over temperature input can be used to continuously monitor an external temperature sensor like an NTC. Specific type of NTC has to be used. Refer to the MCE Reference Manual for details.

**Table 10 Over temperature input**

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
Over temperature input threshold	$V_{OT}$	0.1	1.0	3.0	V	VDD=3.3V, Configurable parameter e.g. via MCEDesigner, default=1.0V
Over temperature to PWM shutdown	$t_{ot}$	-	1.0	2.1	ms	

## Electrical characteristics and parameters

### 4.5.3 Pulse Output

The IMC300 series provide an optional PGOUT pin pulse output. The pulse frequency is proportional to motor revolution. Refer to the MCE Reference Manual for details.

**Table 11 Pulse Output**

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
Pulse per Revolution	$PPR$	4	-	24	PPR	
Pulse duty cycle	$t_{PPR}$	-	50	-	%	

### 4.5.4 LED Output

The IMC300 series provide an output that can be connected to an LED to give a visual indication of the status of the motor drive.

**Table 12 LED Output**

Parameter	Symbol	Limit Values			Unit	Condition
		Min	Typ	Max		
Fault to LED delay	$t_{LEDFault}$	-	53	-	ms	
Fault reset to LED delay	$t_{LEDRESET}$	-	1.84	-	ms	
LED blinking frequency	$f_{LED}$	1		1000	Hz	
LED blinking duty cycle	$t_{LED}$	5		95	%	

## Quality declaration

## 5 Quality declaration

Table 13 Quality Parameters

Parameter	Symbol	Limit Values		Unit	Condition
		Min	Max		
ESD susceptibility according to Human Body Model (HBM)	$V_{\text{HBM}}$ SR	-	2000	V	Conforming to ANSI/ESDA/JEDEC JS-01
ESD susceptibility according to Charged Device Model (CDM) pins	$V_{\text{CDM}}$ SR	-	500	V	Conforming to ANSI/ESDA/JEDEC JS-001
Moisture sensitivity level	$MSL$ CC	-	3	-	JEDEC J-STD-020C
Soldering temperature	$T_{\text{SDR}}$ CC	-	260	°C	Profile according to JEDEC J-STD-020D

---

**Device and Package specification**

## 6 Device and Package specification

### 6.1 SBSL and Chip-IDs

The table below gives the IDs for the individual devices in the IMC300 family. Depending upon the mode either the SBSL-ID (secure boot loader) or the Chip-ID should be used to identify the device.

Both cores of the IMC300 family have a dedicated Chip-ID. The MCE core is programmed via a secure loader using the SBSL-IDs as given below.

For details refer to the Reference Manual or the iMOTION™ Programming Manual.

**Table 14 SBSL and Chip IDs**

Product Type	Core	Chip-ID	SBSL-ID
IMC301A-F048	MCE	0x1B010006	0x026add3f080ad5abfb67af2271ea4973
	ARM® Cortex®-M0	0x13011006	-
IMC301A-F064	MCE	0x1B01000B	0x0207810c349410e8be51722b81520cf8
	ARM® Cortex®-M0	0x1301100B	-
IMC302A-F048	MCE	0x1B020006	0x024747b4b61060cf95f7b14a05b1decc
	ARM® Cortex®-M0	0x13021006	-
IMC302A-F064	MCE	0x1B02000B	0x0216ebe1d4cc0767684bacceefae29b2
	ARM® Cortex®-M0	0x1302100B	-

Device and Package specification

6.2 Package drawings

6.2.1 PG-LQFP-48-11

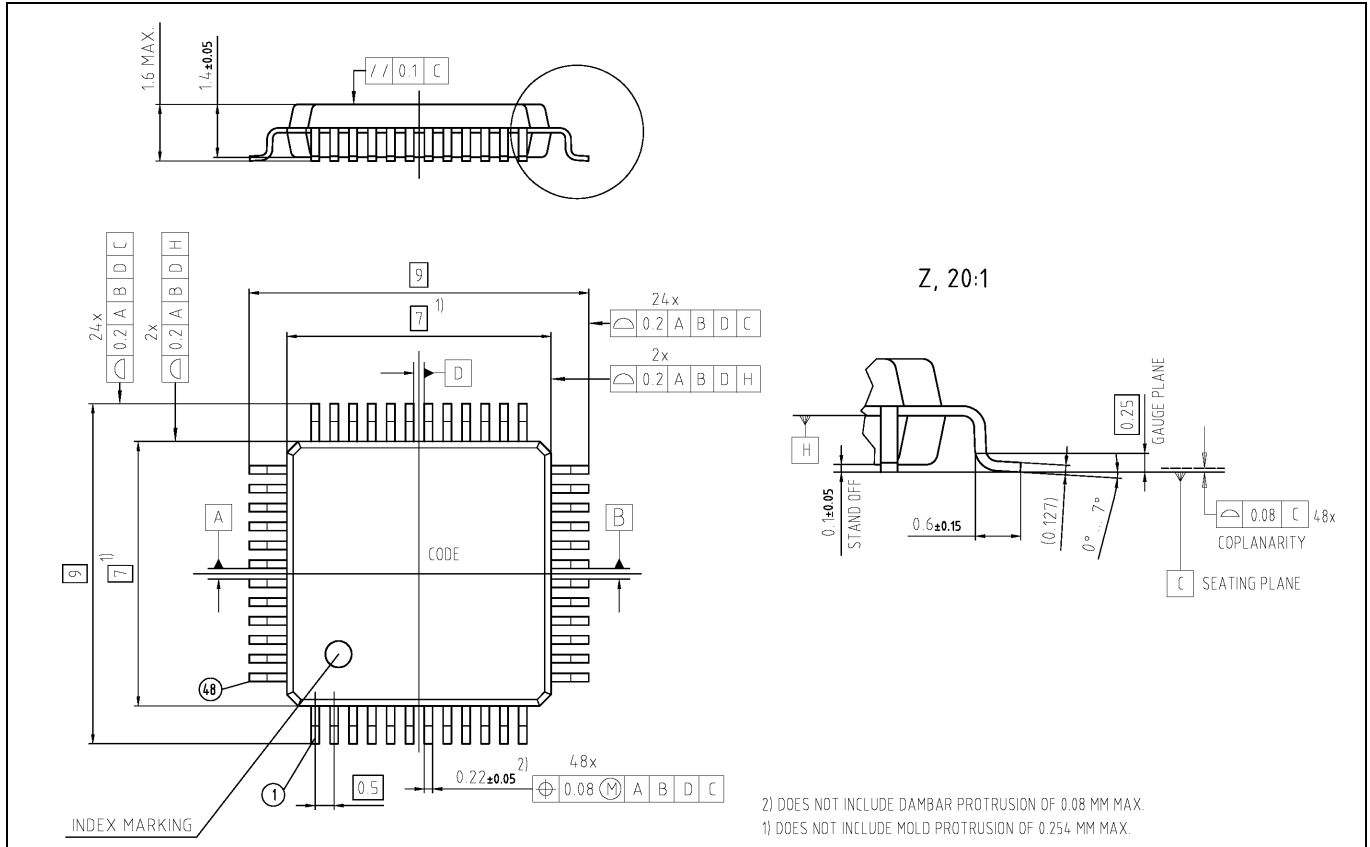


Figure 11 PG-LQFP-48-11

Device and Package specification

6.2.2 PG-LQFP-64-29

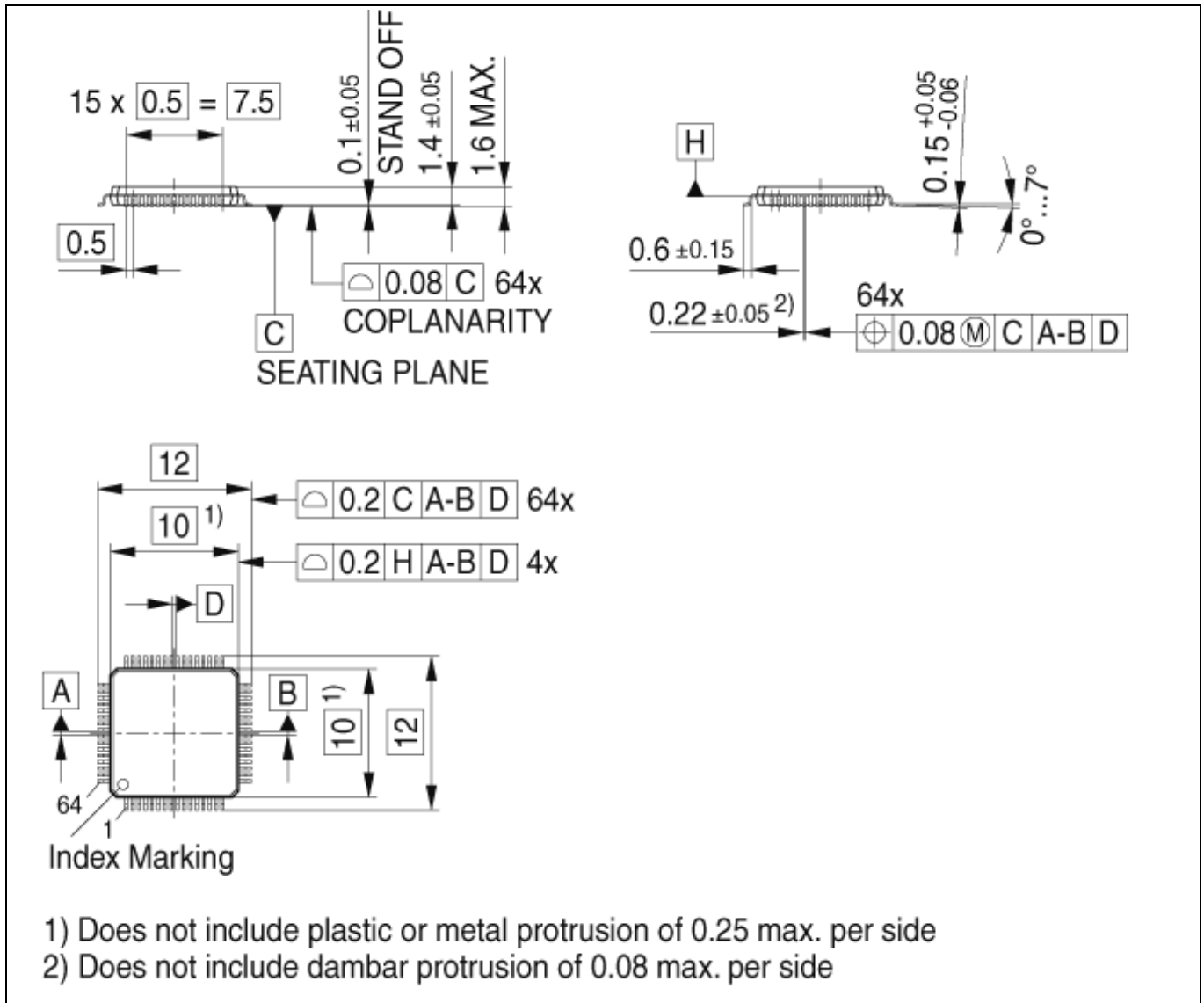


Figure 12 PG-LQFP-64-29

Device and Package specification

6.3 Thermal Characteristics

Table 15 Thermal Characteristics of the packages

Parameter	Symbol	Limit Values		Unit	Condition
		Min	Max		
Thermal resistance Junction-Ambient	R <sub>θJA</sub> CC	-	66.7	K/W	PG-LQFP-64-26
		-	TBD	K/W	PG-LQFP-48-26

Note: For electrical reasons, it is required to connect the exposed pad to the board ground VSSP, independent of EMC and thermal requirements.

When operating the IMC300 in a system, the total heat generated in the chip must be dissipated to the ambient environment to prevent overheating and the resulting thermal damage. The maximum heat that can be dissipated depends on the package and its integration into the target board. The “Thermal resistance R<sub>θJA</sub>” quantifies these parameters. The power dissipation must be limited so that the average junction temperature does not exceed 115°C. The difference between junction temperature and ambient temperature is determined by  $\Delta T = (P_{INT} + P_{IOSTAT} + P_{IODYN}) \times R_{\theta JA}$  The internal power consumption is defined as  $P_{INT} = V_{DD} \times I_{DDP}$  (switching current and leakage current). The static external power consumption caused by the output drivers is defined as  $P_{IOSTAT} = \Sigma((V_{DD} - V_{OH}) \times I_{OH}) + \Sigma(V_{OL} I_{OL})$  The dynamic external power consumption caused by the output drivers (P<sub>IODYN</sub>) depends on the capacitive load connected to the respective pins and their switching frequencies. If the total power dissipation for a given system configuration exceeds the defined limit, countermeasures must be taken to ensure proper system operation:

- Reduce VDD, if possible in the system
- Reduce the system frequency
- Reduce the number of output pins
- Reduce the load on active output drivers

<sup>1</sup> Device mounted on a 4-layer JEDEC board (JESD 51-5); exposed pad of VQFN soldered

Device and Package specification

6.4 Part marking

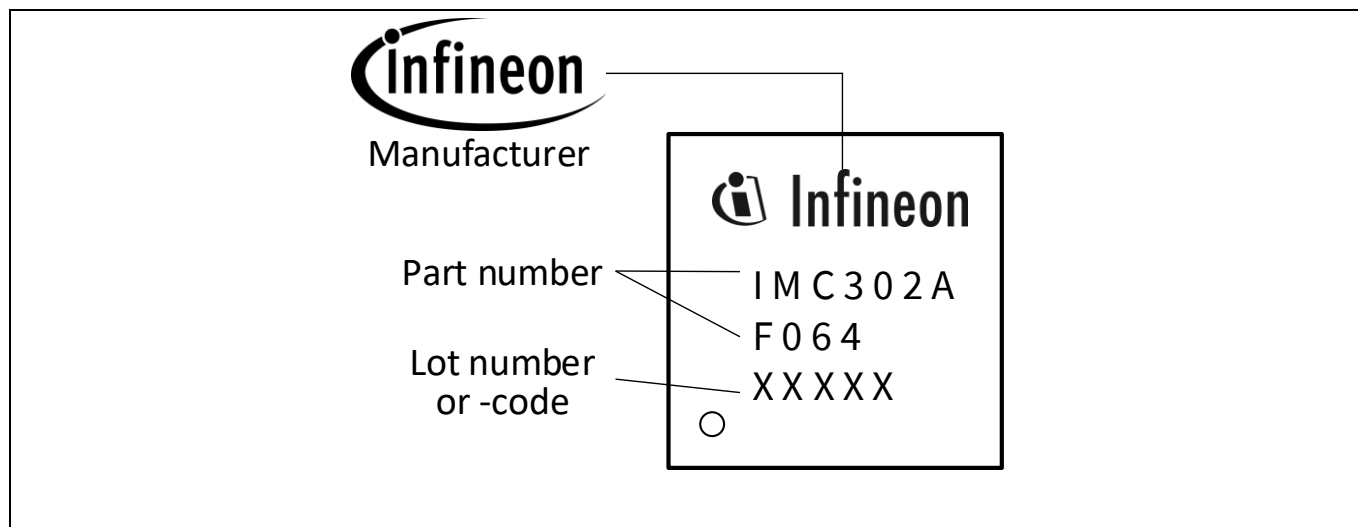


Figure 13 Part marking

Revision history

Document version	Date of release	Description of changes
1.0	2019-12-12	Initial version



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