Melexis
Microelectronic Integrated Systems

MLX81200

BLDC Motor Controller

Features

MelexCM DUAL RISC CPU

- MLX4 communication CPU
  - LIN transceiver, supporting of LIN 2.0, LIN protocol software provided by Melexis
  - Software update for J2602 or GM-LAN possible
  - Wake up by LIN traffic or local sources
- MLX16 application CPU
  - 16bit RISC-CPU with 5MIPS
  - hardware multiplication in one instruction cycle
  - C-programmable
- Memories
  - 2kbyte shared RAM
  - 30kbyte shared Flash with EEC, programmable through LIN pins
    8kbytes for communication CPU, 22kbytes for application CPU
  - 128bytes emulated EEPROM

Motor Control Unit

- Support of sensor less 3-phase sine and trapezoidal motor control
- Support of sensor based motor control
- Pre-driver for 3 all N-FET half bridges (~25Ω Rdson) with several protection features

Voltage Regulator

- Direct powered from 12V board net with low voltage detection
- Operating voltage V_S = 6V to 18V
- Internal voltage regulator, possibility to put an external bypass transistor for higher temperature requirements
- Very low standby current, < 50µA in sleep mode

Periphery

- Full duplex SPI: Master/Slave, double buffered, speed programmable from 10kHz to 8MHz
- 3 independent 16bit timer modules with capture and compare
- 3 programmable 8bit PWM units with base frequency of 50Hz to 100kHz
- 10bit ADC converter (5µs conversion time)
- On chip over-temperature shut-off
- Digital watchdog on MelexCM and independent analog watchdog on analog IC
- On chip RC oscillator
- Switchable supply output for external sensors

Additional Features

- In-circuit debug and emulation
- Jump start and 40V load dump protected

Ordering Code

Product Code	Temperature Code	Package Code	Option Code	Packing Form Code
MLX81200	K	LQ	BAA-000	TU
MLX81200	K	LQ	BAA-000	RE
MLX81200	K	PF	BAA-000	TU
MLX81200	K	PF	BAA-000	RE

Legend:

Temperature Code: K for Temperature Range -40°C to 125°C
Package Code: LQ for QFN, PF for 7x7 EP
Packing Form: RE for Reel, TU for Tube

Ordering example: MLX81200KLQ-BAA-000-TU

Applications

All kinds of BLDC motor controllers via external FET transistors like

- X-by-wire applications using position sensors
- Oil, water, fuel pumps
- Blowers
- Compressors

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Functional Diagram

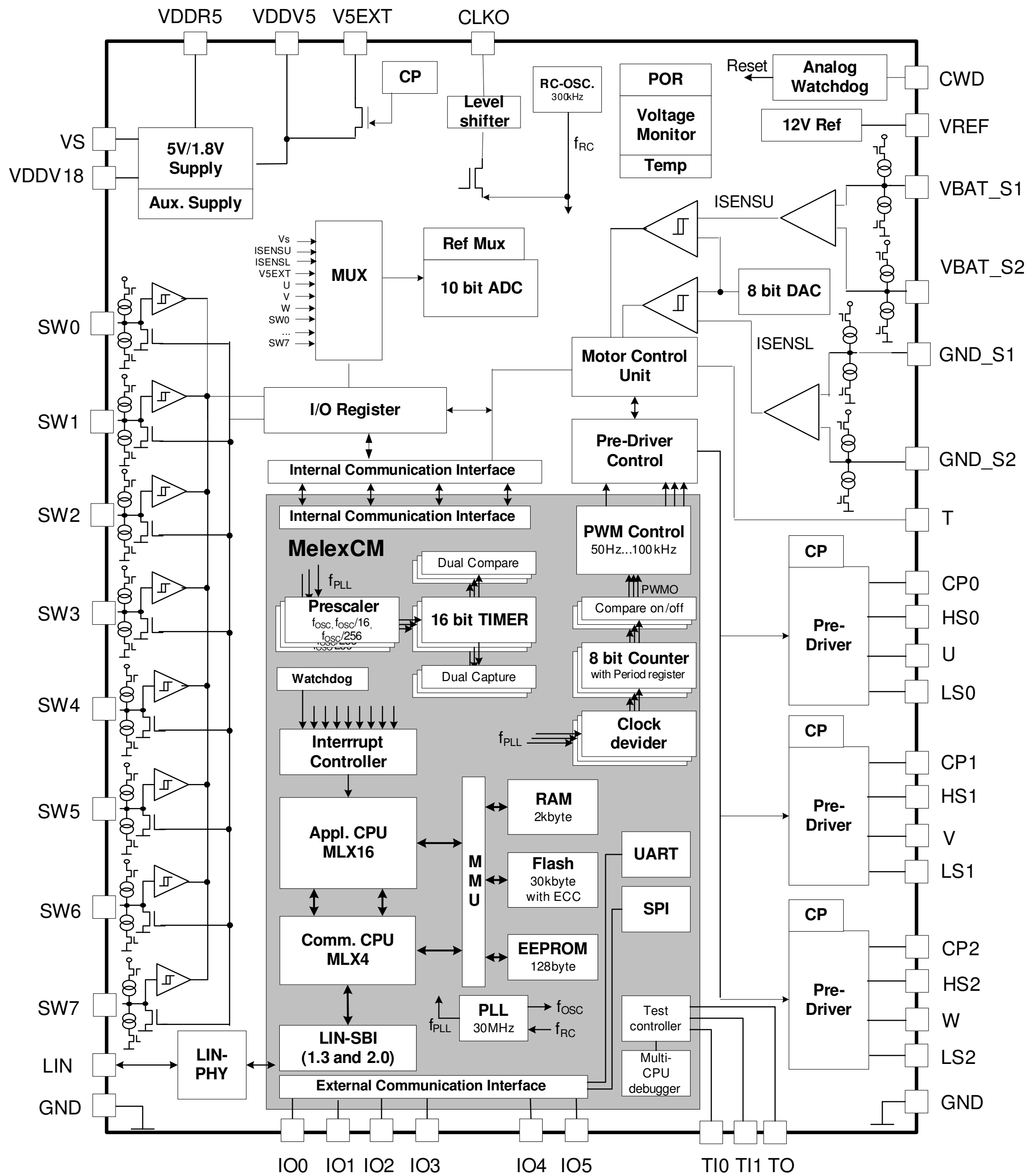

Figure 1 - Block Diagram

1. Electrical Characteristics

All voltages are referenced to ground (GND). Positive currents flow into the IC. The absolute maximum ratings given in the table below are limiting values that do not lead to a permanent damage of the device but exceeding any of these limits may do so. Long term exposure to limiting values may affect the reliability of the device. Reliable operation of the MLX81200 is only specified within the limits shown in Operating conditions.

1.1 Operating Conditions

Parameter	Symbol	Min	Max	Unit
Battery supply voltage	V_S	6	18	V
Operating ambient temperature	T_{amb}	-40	+125 (+150)[1]	°C

Table 1 - Operating Conditions

1.2 Absolute Maximum Ratings

Parameter	Symbol	Condition	Min	Max	Unit
Battery supply voltage	V_S	T < 1 min	-0.3	28	V
		T < 500 ms		45	
Maximum reverse current into any pin	I_{REV}		-10	+10	mA
LIN bus voltage	V_{BUS}	t < 500 ms	-20	40	V
Transient supply voltage	$V_{S.tr1}$	ISO 7637/1 pulse 1 [2]	-150		V
Transient supply voltage	$V_{S.tr2}$	ISO 7637/1 pulses 2 [2]		+100	V
Transient supply voltage	$V_{S.tr3}$	ISO 7637/1 pulses 3A, 3B	-150	+150	V
Transient LIN bus voltage	$V_{BUS.tr1}$	ISO 7637/1 pulse 1 [3]	-150		V
Transient LIN bus voltage	$V_{BUS.tr2}$	ISO 7637/1 pulses 2 [3]		+100	V
Transient LIN bus voltage	$V_{BUS.tr3}$	ISO 7637/1 pulses 3A, 3B [3]	-150	+150	V
DC voltage on CMOS I/O pins	V_{DC}		-0.3	+5.5	V
ESD capability of pin LIN	ESD_{BUSHB}	Human body model, equivalent to discharge 100pF with 1.5kΩ,	-4	+4	kV
ESD capability of any other pins	ESD_{HB}	Human body model, equivalent to discharge 100pF with 1.5kΩ,	-2	+2	kV
Maximum latch–up free current at any Pin	I_{LATCH}		-250	+250	mA
Maximum power dissipation [4]	P_{tot}	T_{amb} = +150 °C[1]		0.2	W
Storage temperature	T_{stg}		-55	+150	°C
Junction temperature [1]	T_{vj}			+155	°C

Table 2 - Absolute Maximum Ratings

[1] Target temperature after qualification. With temperature applications at TA>125°C a reduction of chip internal power dissipation with external supply transistor is mandatory. The extended temperature range is only allowed for a limited period of time, customers mission profile has to be agreed by Melexis as a mandatory part of the Part Submission Warrant.
[2] ISO 7637 test pulses are applied to VS via a reverse polarity diode and >1µF blocking capacitor .
[3] ISO 7637 test pulses are applied to BUS via a coupling capacitance of 1nF.
[4] Simulated value for low conductance board (JEDEC)

2. Application Examples

The following sections show typical application examples[1].

2.1 BLDC Motor Control

In this sample application the IC can realize the sensor less driving of a BLDC motor via three external power N-FET half bridges. The high side N-FET driving is done with a bootstrap output stage. The motor speed command can be sent to an SW-pin, for example as duty cycle percentage. In this case SW4 can be configured as timer input and the motor speed is a function of the duty cycle of the speed command signal.
The rotor position can be estimated based on motor currents at stand-still and very low speeds and by sensing the back EMF voltage during short periods of time when the current through a phase is zero. The motor phases can be driven with sinusoidal or trapezoidal currents. In the principle application schematic of figure 2, the motor star point is not available. Instead it is modelled with external resistors from the motor phases and connected to T input.
Motor current is controlled with an external shunt resistor and a fast internal comparator. The comparator threshold is programmable with an 8-bit digital-to-analogue converter. In case of over current the bridge will be switched off. The motor current can also be measured by the 10-bit ADC converter. Reverse polarity protection of the bridge is realized with an external power FET connected to the ground line.

[1] The application examples are principal application schematics only. The details need to be worked out for each application schematic separately, depending on the application requirements.

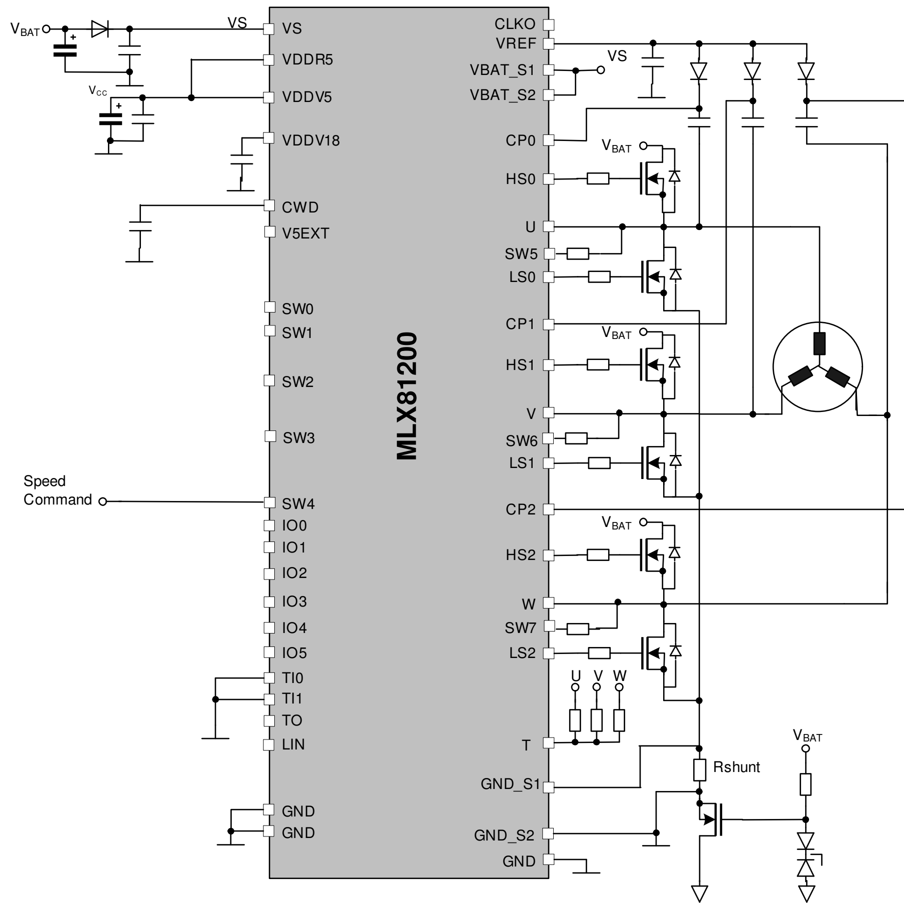

Figure 2 – Typical BLDC Motor Control Application Example [1]

2.2 BLDC Motor Control via LIN Bus Connection

In this sample application the IC can realize the sensor less driving of a BLDC motor via three external power N-FET half bridges. Communication to the chip is possible via the LIN bus. Active high side reverse polarity protection can be implemented using a bootstrap stage connected to the CLKO output.
For higher temperature requirements, an external regulator transistor can bring the regulator power consumption to outside the chip. Two of the general purpose inputs are used to connect external sensors to the ADC. The sensor supply voltage can be switched off. The motor current measurement and over current protection can be implemented via a shunt resistor in the battery path.

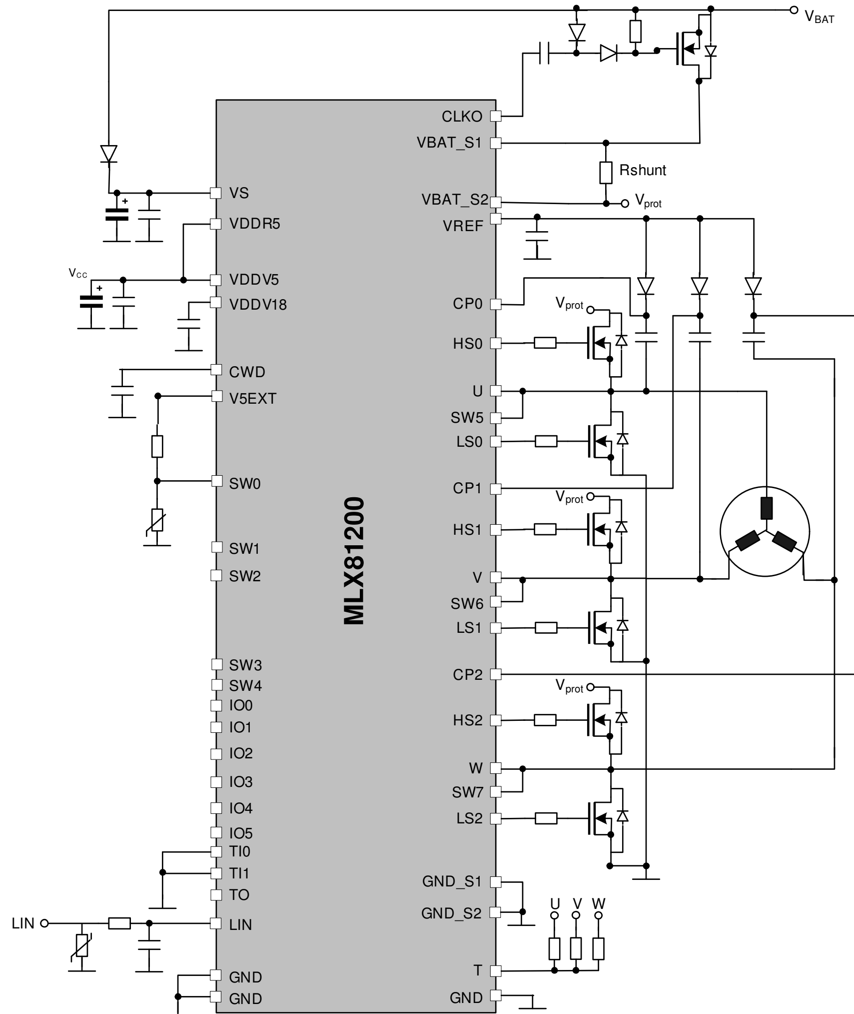

Figure 3 – Typical LIN Bus Application Example with Active Reverse Polarity Protection[2]

[2] The application examples are principal application schematics only. The details need to be worked out for each application schematic separately, depending on the application requirements.

2.3 BLDC Motor Control via CAN Bus Connection

In this sample application the IC can realize the driving of a BLDC motor via three external power N-FET half bridges. Hall sensors are used to determine the rotor position. In case of battery break-down, the IC is still capable to save sensitive data into the EEPROM, with the help of the energy stored in the 5V supply capacitor. The current in both, the supply and ground path can be monitored. The SPI interface is used to connect the IC to the CAN bus.

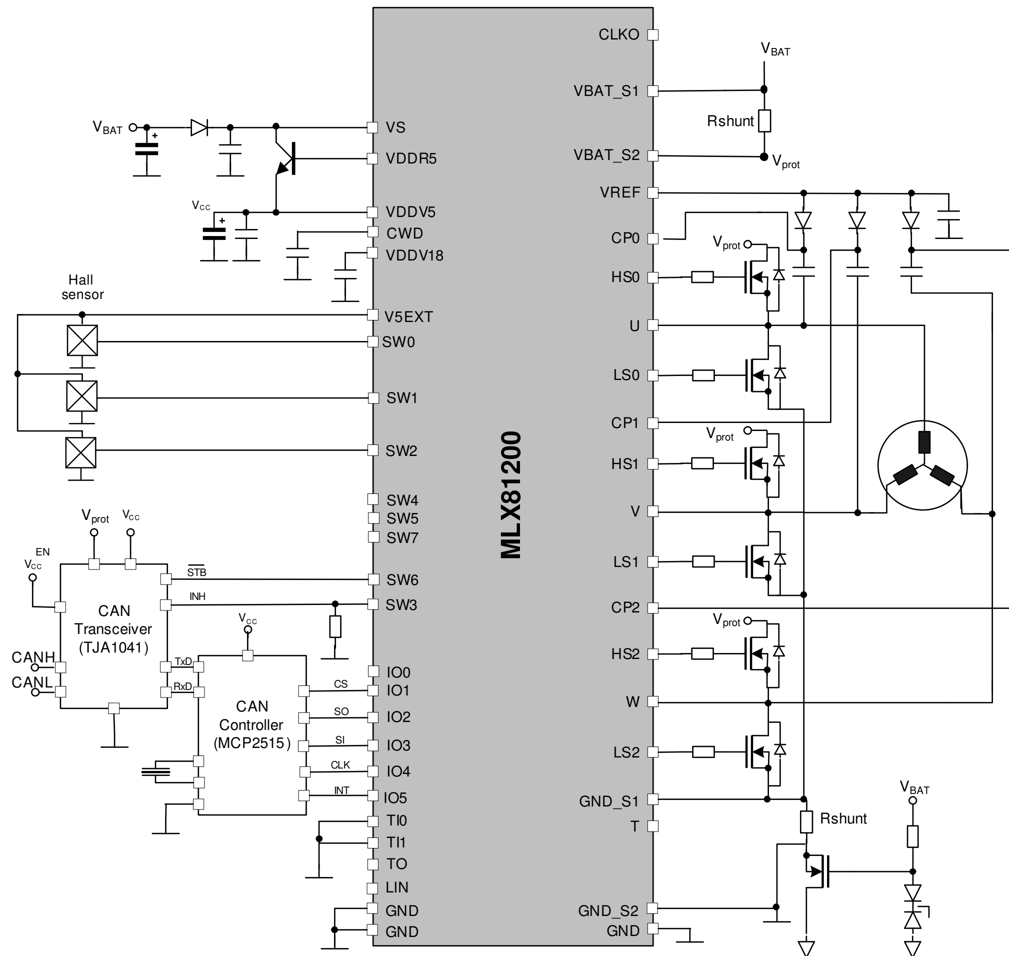

Figure 4 – Typical CAN Bus Application Example[3]

[3] The application examples are principal application schematics only. The details need to be worked out for each application schematic separately, depending on the application requirements.

3. Pin Description

Table 3 - Pin Description MLX81200

Pin №	Name	Type	Function
1	IO0	IO	General purpose input or output
2	V5EXT	IO	Switchable 5V supply for external sensors
3	IO5	IO	General purpose input or output
4	GNDA	GND	Analog ground
5	GNDLIN	GND	LIN ground
6	TO	O	Test output, debug interface
7	IO1	IO	General purpose input or output
8	LIN	IO	Connection to LIN bus
9	IO4	IO	General purpose input or output
10	IO2	IO	General purpose input or output
11	TI1	I	Test input, debug interface
12	IO3	IO	General purpose input or output
13	GNDIO	O	Switches ground
14	TI0	I	Test input, debug interface
15	CLKO	O	300kHz clock output, switchable
16	SW7	IO	HV GPIO, phase W input to BEMF comp and phase integrator
17	SW6	IO	HV GPIO, phase V input to BEMF comp and phase integrator
18	SW5	IO	HV GPIO, phase U input to BEMF comp and phase integrator
19	SW4	IO	HV GPIO
20	SW3	IO	HV GPIO
21	SW2	IO	HV GPIO
22	SW1	IO	HV GPIO
23	SW0	IO	HV GPIO
24	W	I	Motor phase W input to HS2 buffer
25	HS2	O	N-FET high side gate driver 2
26	CP2	O	High side bootstrap capacitor driver 2
27	LS2	O	N-FET low side gate driver 2
28	LS1	O	N-FET low side gate driver 1
29	CP1	O	High side bootstrap capacitor driver 1
30	HS1	O	N-FET high side gate driver 1
31	V	I	Motor phase V input to HS1 buffer
32	GNDDRV	GND	Driver ground
33	U	I	Motor phase U input to HS0 buffer
34	HS0	O	N-FET high side gate driver 0
35	CP0	O	High side bootstrap capacitor driver 0
36	LS0	O	N-FET low side gate driver 0
37	T	I	Electrical commutation input motor phase T
38	VREF	IO	Clamped 12V reference voltage for bootstrap
39	VBAT_S1	I	VS high side input for current sensing
40	VBAT_S2	I	VS low side input for current sensing

41	GND_S1	I	GND high side input for current sensing
42	GND_S2	I	GND low side input for current sensing
43	VS	P	HV supply, battery voltage
44	GNDD	GND	Digital ground
45	VDDV18	P	Regulator Output 1.8V, MELEXCM 1.8V supply
46	VDDR5	O	Output for external voltage regulation transistor
47	VDDV5	P	Regulator Output 5V, MELEXCM 5V supply
48	CWD	IO	Watchdog capacitor

4. Mechanical Specification

4.1 QFN 7x7 (48 leads)

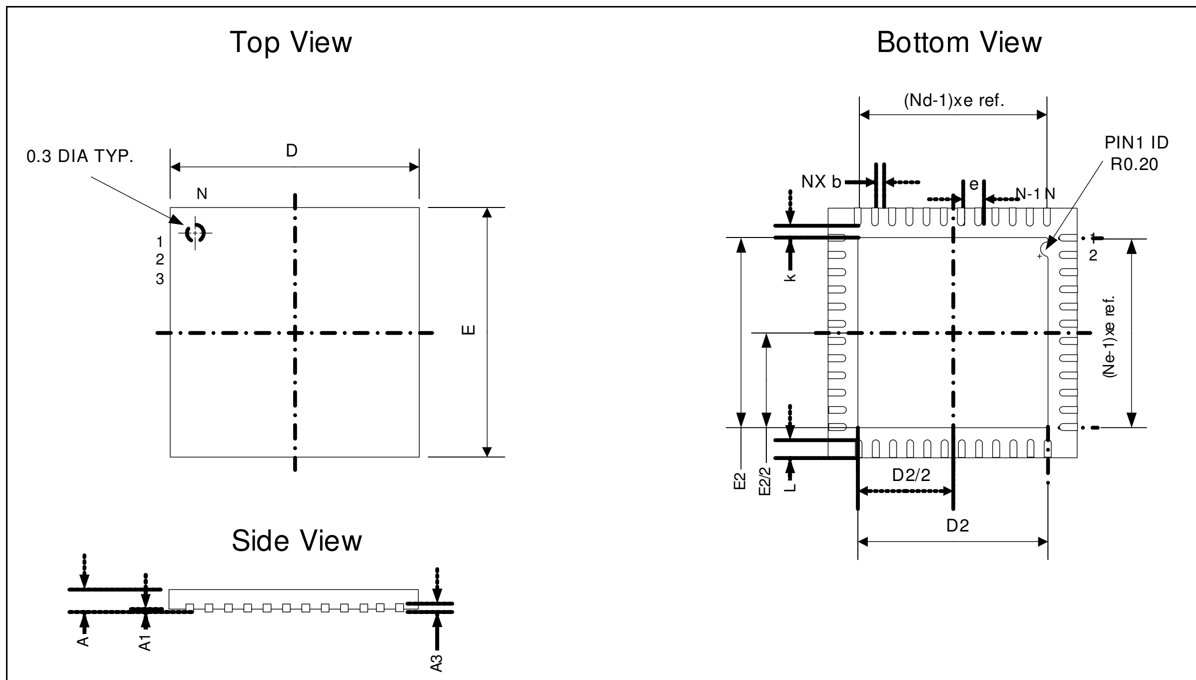

Figure 3 - QFN48 7x7 Drawing

Symbol		A	A1	A2	A3	B [4]	D	D1	D2	E	E1	E2	e	L	N [3]	Nd [5]	Ne [5]	
QFN48	min	0.80	0	0.60					5.30			5.30		0.45				
	nom	0.85	0.02	0.65	0.20		7.00	6.70	5.40	7.00	6.70	5.40	0.50	0.50	48	12	12	[1] [2]
	max	0.90	0.05	0.70		12°			5.50			5.50		0.55				

Table 4 - QFN48 7x7 Package Dimensions

[1] Dimensions and tolerances conform to ASME Y14.5M-1994
[2] All dimensions are in millimeters. All angels are in degrees

[3] N is the number of terminals
[4] Dimension b applies to metallized terminal and is measured between 0.25 and 0.30mm from terminal tip
[5] Nd and Ne refer to the number of terminals on each D and E side respectively

4.2 TQFP_EP 7x7 (48 leads)

	A	A1	A2	b	b1	D	D1	D2	E	E1	E2	e	L	N	ccc	ddd
Min	-	0.05	0.95	0.17	0.17								0.45		-	-
Nom	-	-	1.00	0.22	0.20	9.00	7.00	5.00	9.00	7.00	5.00	0.50	0.60	48	-	-
Max	1.20	0.15	1.05	0.27	0.23								0.75		0.08	0.08

Notes:
1. All Dimensioning and Tolerances conform to ASME Y14.5M-1994,
Δ2. Datum Plane [-|-|-] located at Mould Parting Line and coincident with Lead, where Lead exists, plastic body at bottom of parting line.
Δ3. Datum [A-B] and [-D-] to be determined at centreline between leads where leads exist, plastic body at datum plane [-|-|-]
Δ4. To be determined at seating plane [-C-]
Δ5. Dimensions D1 and E1 do not include Mould protrusion. Dimensions D1 and E1 do not include mould protrusion. Allowable mould protrusion is 0.254 mm on D1 and E1 dimensions.
6. 'N' is the total number of terminals
Δ7. These dimensions to be determined at datum plane [-|-|-]
8. Package top dimensions are smaller than bottom dimensions and top of package will not overhang bottom of package.
Δ9. Dimension b does not include dam bar protrusion, allowable dam bar protrusion shall be 0.08mm total in excess of the "b" dimension at maximum material condition, dam bar can not be located on the lower radius of the foot.
10. Controlling dimension millimetre.
11. maximum allowable die thickness to be assembled in this package family is 0.38mm
12. This outline conforms to JEDEC publication 95 Registration MS-026, Variation ABA, ABC & ABD.
Δ13. A1 is defined as the distance from the seating plane to the lowest point of the package body.
Δ14. Dimension D2 and E2 represent the size of the exposed pad. The actual dimensions are specified ion the bonding diagram, and are independent from die size.
15. Exposed pad shall be coplanar with bottom of package within 0.05.

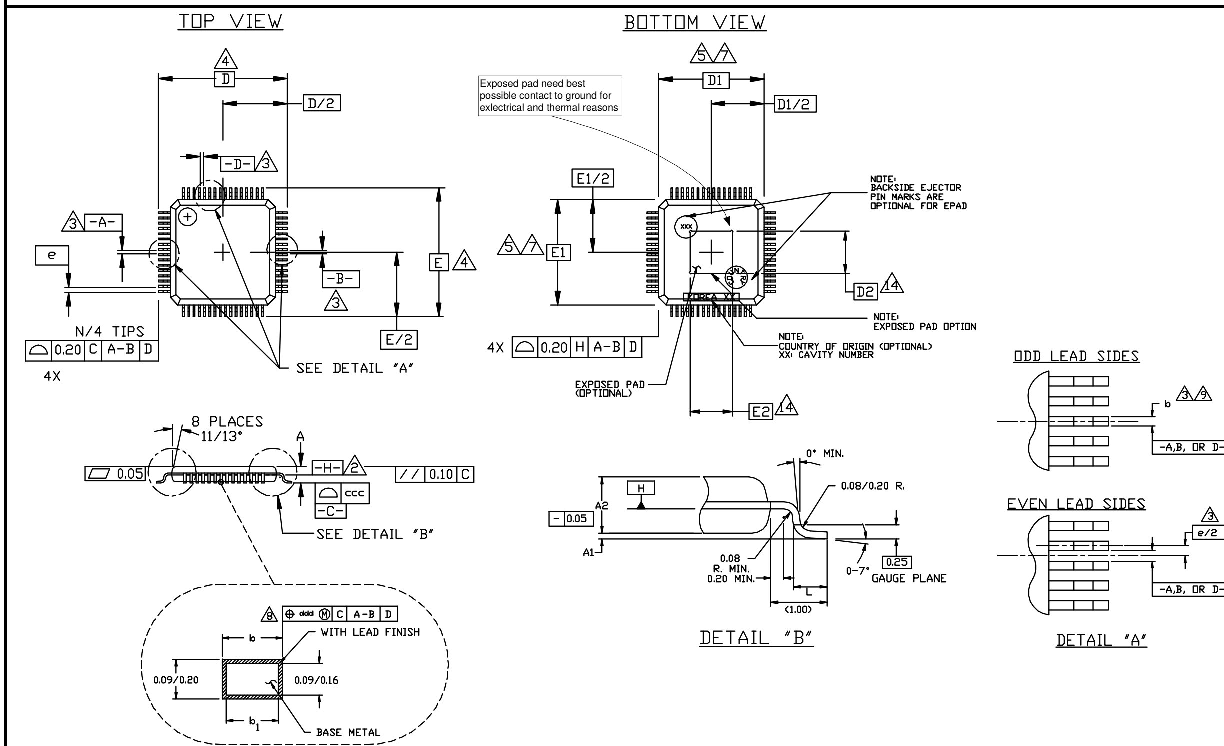

Figure 4 – TQFP_EP 7x7 Drawing

5. Standard information regarding manufacturability of Melexis products with different soldering processes

Our products are classified and qualified regarding soldering technology, solderability and moisture sensitivity level according to following test methods:

Reflow Soldering SMD's (Surface Mount Devices)

- IPC/JEDEC J-STD-020
  Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices
  (classification reflow profiles according to table 5-2)
- EIA/JEDEC JESD22-A113
  Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing
  (reflow profiles according to table 2)

Wave Soldering SMD's (Surface Mount Devices) and THD's (Through Hole Devices)

- EN60749-20
  Resistance of plastic- encapsulated SMD's to combined effect of moisture and soldering heat
- EIA/JEDEC JESD22-B106 and EN60749-15
  Resistance to soldering temperature for through-hole mounted devices

Iron Soldering THD's (Through Hole Devices)

- EN60749-15
  Resistance to soldering temperature for through-hole mounted devices

Solderability SMD's (Surface Mount Devices) and THD's (Through Hole Devices)

- EIA/JEDEC JESD22-B102 and EN60749-21
  Solderability

For all soldering technologies deviating from above mentioned standard conditions (regarding peak temperature, temperature gradient, temperature profile etc) additional classification and qualification tests have to be agreed upon with Melexis.

The application of Wave Soldering for SMD's is allowed only after consulting Melexis regarding assurance of adhesive strength between device and board.

Melexis is contributing to global environmental conservation by promoting **lead free** solutions. For more information on qualifications of **RoHS** compliant products (RoHS = European directive on the Restriction Of the use of certain Hazardous Substances) please visit the quality page on our website: http://www.melexis.com/quality.aspx

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Your Notes