QD-1010Lite

High Speed, High Resolution Digital IDDQ Monitor

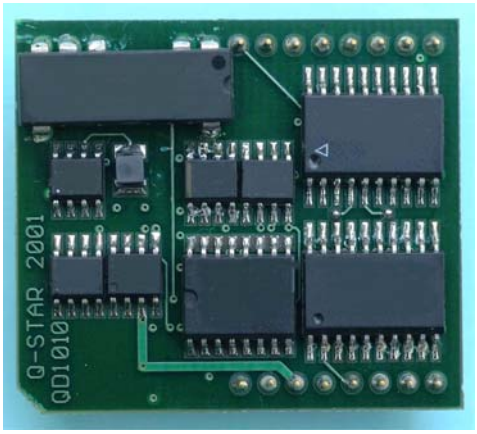
FEATURES

- Wide DUT Supply range: V_{DUT} = 0.5V to 7V
- Wide measurement range: I_{DDQ} = 0 – 30mA
- Typical measurement time: 200 µs
- High capacitive driving capability: up to 10µF
- High single sample resolution: 50nA$_{RMS}$
- 16-bits I_{DDQ} Value Read Out
- 3-Wire Serial Configuration/Read out Interface

APPLICATIONS

- ATE Load Board Applications
- I_{DDQ} Pass/Fail Measurements
- I_{DDQ} Read Out Measurements

DESCRIPTION



The QD-1010Lite is a version of the advanced QD-1010 I_{DDQ} monitor with reduced functionality. The QD-1010Lite is designed for load board applications and supports standard I_{DDQ} measurements. The module provides 16-bit digital measurement values as well as a pass/fail output signal. In contrast with the full-featured QD-1010, the QD-1010Lite has no on-board memory and data processing capabilities supporting advanced measurement strategies.

The QD-1010Lite operates according to the Stabilised Voltage Drop principle and is designed for insertion between the Automated Test Equipment (ATE) device power supply and the supply pin(s) of the Device Under Test (DUT). There is no need to remove the local decoupling capacitors. Its unique design ensures transparency to both the ATE and DUT, under all conditions. The unit can drive high capacitive loads (up to several µF) and causes only a negligible voltage drop during the measurement.

The QD-1010Lite offers the capability to perform accurate (better than 50nA @ 5kHz) and highly repeatable high speed (up to 5kHz) quiescent supply current measurements.

The module has a wide measurement range (0-30mA). The serial output provides the Pass/Fail flag and/or the measured I_{DDQ} value with a 16-bit resolution. The QD-1010Lite requires only a single positive supply, and provides, under all conditions, a stable, guaranteed and user programmable (0.5 to 7V) DUT supply level.

The QD-1010Lite has an on-board compensated bypass switch, which minimises charge transfers. Its switch is capable of transferring large transient currents. To assure DUT supply stability, the bypass switch is automatically activated when the measured current is out of the monitor's measurement range.

By default the QD-1010Lite's Current Measurement Unit (CMU) is optimised to perform an I_{DDQ} measurement in 200µs for a 100nF to 10µF capacitive load. The default measurement range of the QD-1010Lite is set to 0-1mA with a measurement resolution of 90nA$_{RMS}$. Other possible fixed measurement ranges are 0-100µA, 0-10mA, 0-30mA with a measurement resolution of 20nA$_{RMS}$, 360nA$_{RMS}$ and 1.2µA$_{RMS}$.

In addition to the digital readout capabilities, the QD-1010Lite also provides an analogue output *VIDDQ* that can be measured by the ATE.

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ELECTRICAL SPECIFICATIONS

V_{CC} = +5.0V ±500mV, V_{DUT} = +5.000V ±1mV, T = +25°C

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
Power Supply					
V_{CC}	Positive Supply Voltage	+4.5	+5.0	+5.5	V
I_{CC}	Supply Current		+180	+500 (1)	mA
Measurement Characteristics					
CMR	Current Measurement Range	0.1	1	30 (3)	mA
V_{DUT}	DUT Supply Voltage	0.5	3 - 5	7	V
$t_{MEASURE}$	Measurement Time	(2)	200		µs
f_{-3dB}	Analog bandwith in measurement mode		20		
C_L	External loading capacitance	0	1	10	µF
	Internal QD-1010Lite decoupling capacitance		10		nF
VI_{VIDDQ}	V/I Conversion Ratio	0.5	5	50	mV/µA
GE_{VIDDQ}	DC gain error @ I_{DDQ} = 50%FS		±0.1		%FS
OE_{VIDDQ}	DC offset error @ I_{DDQ} = 0	0	+0.05		%FS
Bypass Characteristics					
I_{DDT}	Transient Current			30	A
R_{ON}	On Resistance		30		mΩ
t_{on}	Bypass Switch On Time		4	6	µs
t_{off}	Bypass Switch Off Time			15	µs
Analogue Input					
C_{IN}	Input capacitance VDUT terminal		22 (4)		µF
R_{INT}	Internal resistance of DUT pin in measurement mode (5)	1	5	10	Ω
V_{INT}	Voltage drop between VDUT pin and DUT pin in measurement mode @ full range value			10	mV
L_{INT}	Parasitic inductance between VDUT pin and DUT pin		25		nH
Digital I/O					
V_{IH}	Digital Input High Voltage (Except RESET)	0.6 V_{CC}		V_{CC} +0.5	V
V_{IH1}	Digital Input High Voltage (RESET)	0.85 V_{CC}		V_{CC} +0.5	V
V_{IL}	Digital Input Low Voltage	-0.5		0.3 V_{CC}	V
V_{OH}	Digital Output High Voltage (I_{OH} = 300µA)	V_{DUT}-0.7			V
V_{OL}	Digital Output Low Voltage (I_{OL} = -6mA)			0.6	V

NOTES:

(1) For proper operation, V_{CC} must be able to provide a 500mA start-up (peak) current required by the DC-DC converter during power-up of the module. After power-up, the current required by the QD-1010Lite is typically 180mA.
(2) The QD-1010Lite can be used to perform static measurements
(3) The maximum measurement range is dependent on the DUT supply voltage for measurement ranges of 10mA or higher. For a 10mA module and V_{DUT} upto 5V, I_{DDQmax} is 10mA. I_{DDQmax}=8mA @ V_{DUT}=6V, I_{DDQmax}=6mA @ V_{DUT}=7V. For a 20mA module and V_{DUT} upto 5V, I_{DDQmax} is 20mA. I_{DDQmax}=16mA @ V_{DUT}=6V, I_{DDQmax}=12mA @ V_{DUT}=7V. For a 30mA module and V_{DUT} upto 5V, I_{DDQmax} is 30mA. I_{DDQmax}=24mA @ V_{DUT}=6V, I_{DDQmax}=18mA @ V_{DUT}=7V.
(4) Typically an on-board 22µF decoupling capacitor is present on the VDUT analogue input. This value can be changed on demand.
(5) Depends both on the module measurement range and driving capability.

ACCURACY & RESOLUTION

The accuracy and measurement resolution of the QD-1010Lite is function the measurement range and the capacitive loading condition, as listed in the table below.

$\Delta I_{DDQ\ RMS} = f(C_L)$ [nA] (4)			
Measurement Range (1)	**C_L**		
	0.0 – 0.5 µF(2)	**0.5 – 2.0 µF(2)**	**1.0 – 10.0 µF(3)**
0 – 100 µA	*20*	*50*	*330*
0 – 1 mA	*50*	*90*	*500*
0 – 10 mA	*360*	*400*	*550*
0 – 30 mA	*2200*	*2200*	*2200*

(1) The measurement range of the QD-1010Lite module is fixed upon assembly.
(2) Module optimized for C_L=1µF
(3) Module optimized for C_L=10µF
(4) If the V_{DUT} power supply injects a high amount of external noise such as switching noise, the noise inside the 20kHz module input bandwidth will be added to monitor's inherent noise and the total resolution will be degraded, especially at high I_{DDQ} and high C_L values.

ABSOLUTE MAXIMUM RATINGS

PARAMETER	WITH RESPECT TO	MIN	MAX	UNITS
V_{CC}	GND	-0.5	+ 7	V
V_{DUT}	GND	-0.5	+ 10	V
Digital Inputs	GND	-0.5	V_{CC} + 0.5	V
Digital Output	GND	-0.5	V_{CC}	V
Digital Output	GND	-50	0	mA
I_{DDT}	GND		30 (1)	A
Operating Temperature Range		0	+70	°C
Storage Temperature		-40	+80	°C
Lead Temperature (10sec) (2)			+220	°C

(1) Duration of the current pulse 1ms max, duty ratio 1% max.
(2) Manual soldering is recommended using SnPB solder

NOTE: Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum ratings for extended periods may affect device reliability.

OPERATING MODES

The QD-1010Lite has two main operating modes, namely bypass and measurement mode. During bypass mode the monitor provides a low resistance path between ATE supply and DUT. During measurement mode the actual measurement takes place. When operating in bypass, the desired pass/fail level can be set using a simple programming protocol. The minimal bypass time is function of the switching time of the DUT.

The measurement operation takes 200µs. At the end of the measurement period, a pass/fail flag at the PF/DOUT output indicates the pass/fail result of the measurement (logic '1' = pass, measurement below reference; logic '0' = fail, measurement above reference). When in measurement mode the module is acting as DUT power supply. When during measurement mode the measured current is out of the monitor's measurement range, then the QD-1010Lite automatically switches back to bypass mode, meanwhile indicating a fail situation. Figures 1 and 2 show a general application diagram as well as a typical measurement cycle.

More information on how to perform measurements with the QD-1010Lite can be found in application note AN0042.

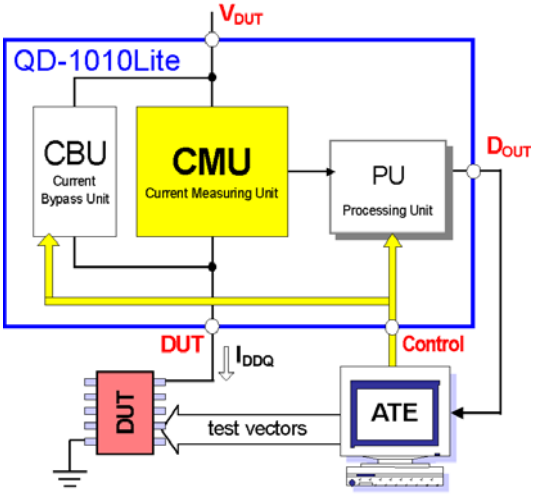


Figure 1. QD-1010Lite Application

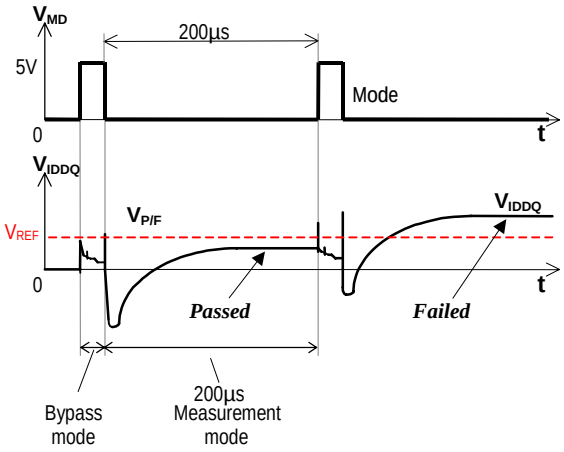


Figure 2. QD-1010Lite Typical Measurement Cycle

DATA PROTOCOLS OF THE QD-1010LITE

The QD-1010Lite accepts an input data stream only when operating in bypass mode, as illustrated in figure 3. The QD-1010Lite supports a double data rate protocol, the data provided on the MD pin is read on both edges of the CLK signal. Even though data is loaded using the MD input, which normally is used to select between bypass and measurement mode, the bypass switch of the module remains active during the data entry phase.

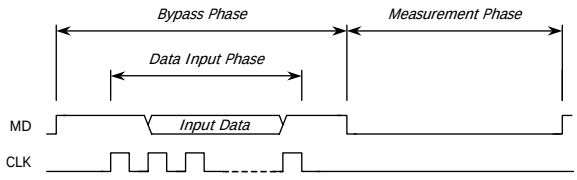


Figure 3. QD-1010*Light* input data stream timing.

The 16-bits pass/fail reference value provided through the input data stream is loaded into the QD-1010Lite's on-board registry.

The QD-1010Lite also supports the read back of the measurement value as a serial bit string. This overcomes the limitations imposed by the ATE due the time needed by the ATE resources to measure the analog output voltage and the potential measurement resolution problem of the ATE instrumentation. The ability of the ATE to convert the bit string into a value may be the limiting factor to use this option. The read back can be done either

during bypass mode or during the measurement phase (i.e. at the end of an I_{DDQ} measurement) and is shifted out at the DOUT output synchronised by the CLK pin, as illustrated in figure 4. The QD-1010Lite supports a double data rate protocol.

The base communication protocols are described in detail in application note AN0042.

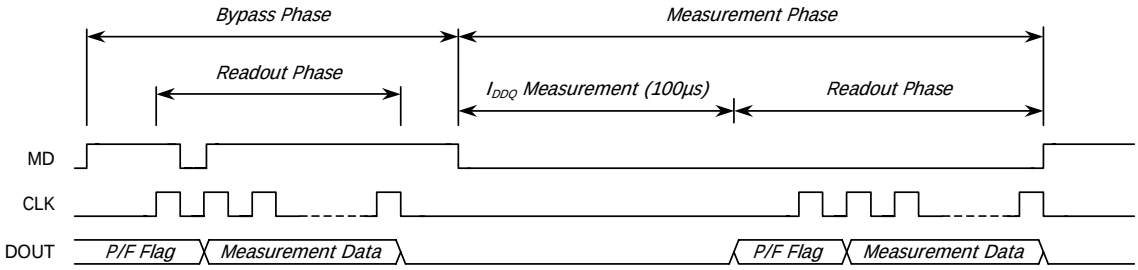


Figure 4. QD-1010Lite output data stream timing.

NOTES:

1. To assure that the monitor always starts operating from a well-known state, an internal power on reset circuit ensures bypass operation. During power-up the Pass/Fail reference is cleared; as a result the QD-1010Lite needs to be reconfigured each time after a power-down, power-up cycle. The power-up cycle takes maximum 25ms.
2. After power-up, it takes an additional 50µs before the bypass is fully closed. During that time no DUT switching actions should be performed.

TYPICAL APPLICATIONS

- The QD-1010Lite can be used as a pass/fail (P/F) monitor,
- The QD-1010Lite can be used as a measurement device to determine the exact value of the measured current. The monitor digitises the measured value with a 16-bit resolution. This value can be read out using the serial interface.

APPLICATIONS HINTS

The requirements/recommendations to guarantee optimum performance of the QD-1010Lite module are listed below:

- The QD-1010Lite should be placed as close as possible to the DUT. The recommended orientation of the module is so that pin 3 is located as close as possible to the DUT, see figure 5. Preferably this pin is connected using a plane.
- All connections to the QD-1010Lite should be well designed not to degrade the monitor's accuracy.
- The ATE is expected to deliver a good quality V_{DUT} reference signal (DUT supply voltage reference) for the DUT. The VDUT pin must ***not*** be left ***floating***. Preferably these pins are connected using a plane.
- The value of the on-pin decoupling capacitance (C_L) is preferable in the 100nF – 1µF range, higher values can be handled but increase the monitor's susceptibility to external noise.
- Global decoupling capacitors should be placed at the VDUT side of the monitor.
- Although the QD-1010Lite has on-board decoupling, it is recommended to decouple V_{CC} and V_{DUT} also externally by ceramic multilayer capacitors 100nF close to the supply and ground pins.
- For optimal performance of the QD-1010Lite monitor, the AGND pin and the GND pin must be connected to the same ground level as the DUT supply being monitored. Preferably these pins are connected using a ground plane.

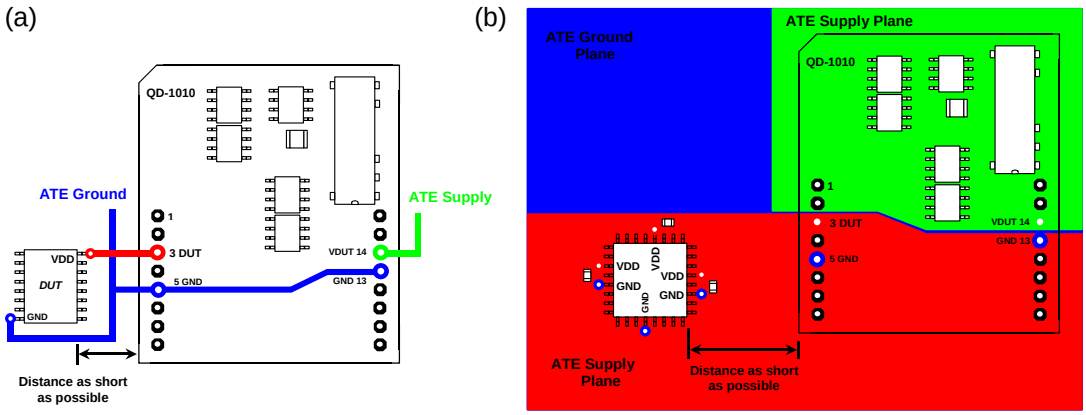


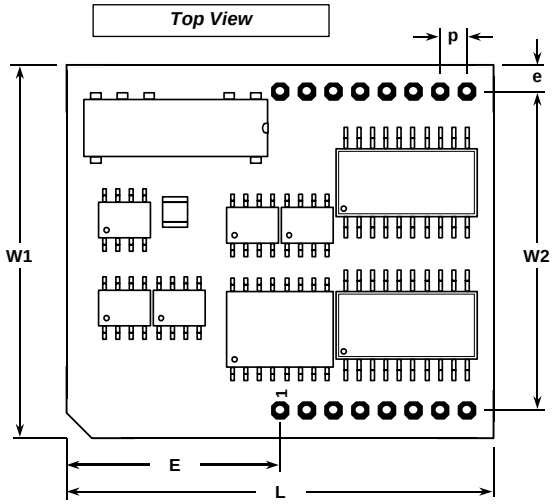
Figure 5. Recommended PCB layout (a) using supply traces, (b) using supply planes.

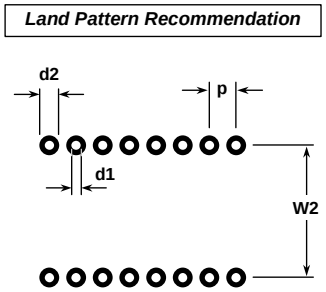
PACKAGE & PIN DESCRIPTION

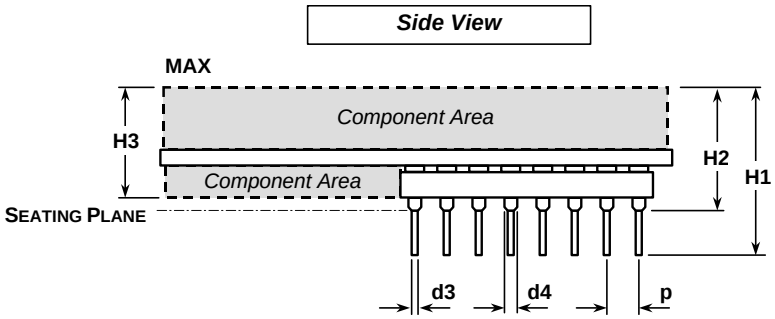
The QD-1010Lite interface board has a 16 pins footprint. The pin description and package dimensions are given below.

PIN #	NAME	TYPE	FUNCTION
1	MD (4)	I	Mode control (“H” = Bypass, “L” = Measurement) – Serial Data input
2	NC		Not connected
3	DUT	O	DUT supply pin
4	NC		Not connected
5	AGND (7)	S	Monitor ground for VDUT, DUT and VIDDQ
6	DOUT (1)(6)	O	Pass/Fail flag – Serial Data output
7	$\overline{\text{RESET}}$ (4)(5)	S	Monitor reset
8	RSP (2)	S	Reserved system pin
9	NC		Not connected
10	NC		Not connected
11	NC		Not connected
12	VCC (3)	S	Positive supply voltage
13	GND (7)	S	Monitor ground
14	VDUT (8)	I	DUT supply reference input
15	VIDDQ	O	Buffered analog output of the Current Measurement Unit
16	CLK	I	Clock input

(1) By default, the digital output is connected to VDUT via an on-board pull-up resistor. Upon request, this on-board pull-up resistor can be omitted creating an “open drain” output allowing the QD-1010Lite to interface to any logic voltage scheme using an external pull-up resistor, or can be connected to VCC using an on-board pull-up resistor.
(2) This pin must be left floating for proper operation of DOUT.
(3) For proper operation, VCC must be able to provide a 500mA start-up (peak) current required by the DC/DC converter during power-up of the module. After power-up, the current required by the QD-1010Lite is typically 180mA.
(4) This pin is pulled up internally, no external pull-up resistor is required. The QD-1010Lite is reset when a low level is present on the RESET pin for more than 50ns. A module reset takes maximum 25ms starting from the rising edge of the reset signal, during this reset period no module communication should occur.
(5) There is no requirement to connect the reset pin for normal operation of the QD-1010Lite. This pin can be left floating.
(6) A pass/fail flag at the DOUT output indicates the pass/fail result of the measurement (logic ‘1’ = pass, logic ‘0’ = fail).
(7) For optimal performance of the QD-1010Lite monitor, the AGND pin and the GND pin must be connected to the same ground level as the DUT supply being monitored. Preferably these pins are connected using a ground plane.
(8) The VDUT pin must be permanently connected to a voltage source and must not be left floating.







Unit	W1	W2	L	p	d1	d2	d3	d4
inches	1.40	1.20	1.60	0.10	0.035	0.067	0.020	0.039
mm	35.56	30.48	40.64	2.54	0.90	1.70	0.50	1.00

Unit	H1	H2	H3	E	e
inches	0.591	0.453	0.354	0.80	0.10
mm	15.00	11.50	9.00	20.32	2.54

LIST OF APPLICATION NOTES

AN0042 Performing measurements with the QD-1010Lite