承永資訊科技
CYRUSTEK CO.

ES168/ES169
LCR meter chipset

Features

- 19,999 counts LCD display
- LQFP-48L package for ES168
- LQFP-80L package for ES169
- Auto identification check and measurement
- Series/Parallel modes are selectable
- R/L/C with D/Q/θ parameters
- Support DCR mode 20.000Ω~20.00MΩ
- 32 different test frequencies are available: 100-250k Hz
- Test ac signal level: 1.0/0.5/0.25V_{RMS} typ.
- 5 range resistor range used
- Test range: (ex. F=1kHz)
  L: 20.000 μH ~ 2.0000 kH
  C: 200.00 pF ~ 2.000 mF
  R: 20.000 Ω ~ 20.00MΩ
- Multi-level battery voltage detector
- Support Backlight & Buzzer sound driver
- Source resistance depends on range
  Typical: 120Ω
- Support UART access.
- Open/Short calibration for AC impedance measurement is allowed:
  Open condition requirement: Impedance is necessary to be larger than 9.5MΩ @ 1kHz
  Short condition requirement: Impedance is necessary to be less than 1.1Ω

Application

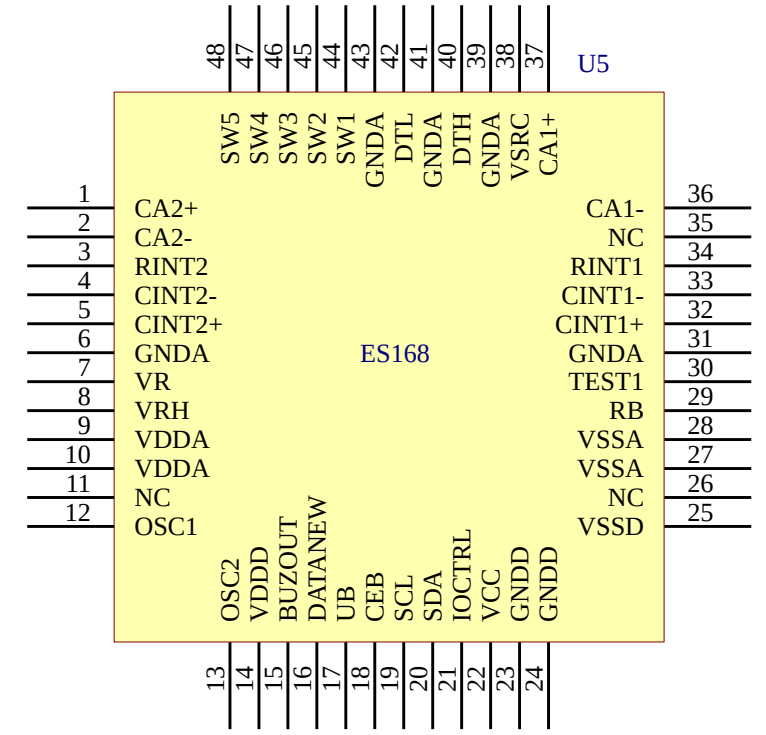
Handheld LCR bridge meter

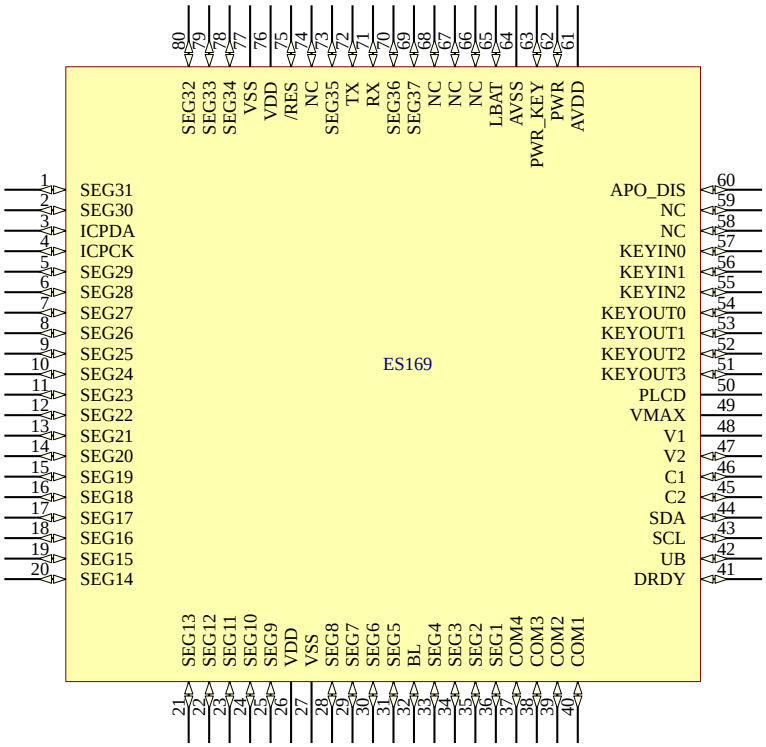
Description

The chipset of ES169/ES168 is suitable for LCR bridge application. By using ES169/ES168 to implement the LCR bridge meter, the complicated PCB design is not necessary. The ES168 is the analog frond end chip with resistor switches network to provide different ranges control. It also provides a high-performance integrated circuit by the signal with different frequency to measure the complex impedance of the DUT (device under test). The ES169 is the mix-mode processing chip to handle the calculation of the D/Q/θ parameter with R/L/C values. It also provides the user interface and LCD drivers to support dual display operation. Tolerance function, limit function, hold function, Max/Min. function and relative function are including in the dual display operation. A multiple-level battery detection and auto power-off scheme are built-in to help the improvement of battery life. The high performance of 4 1/2 digits ADC circuit design is implemented in the ES169/ES168 chipset. A fully smart measurement for L/C/R is possible. User could measure the DUT impedance simply without change function key at the AI mode.

Content

Pin Assignment





Pin Description

ES169

Pin No	Symbol	Type	Description
1-2	SEG31-SEG30	O	LCD segment31-30 output
3	ICPDA	I/O	Data port for In-Circuit Programming
4	ICPCK	I	Clock port for In-Circuit Programming
5-25	SEG29-SEG9	O	LCD segment29-9 output
26	VDD	P	Positive power supply, 3V
27	VSS	P	Negative power supply, ground
28-31	SEG8-SEG5	O	LCD segment8-5 output
32	BL	O	Backlight driver output.
33-36	SEG4-SEG1	O	LCD segment4-1
37-40	COM4-COM1	O	LCD common output
41	DRDY	I	Data ready detection input
42	UB	I	Unbalance detection input
43	SCL	O	Serial bus clock
44	SDA	I/O	Serial bus data
45	C2	-	LCD voltage pump
46	C1	-	LCD voltage pump
47	V2	P	LCD voltage pump
48	V1	P	LCD voltage pump
49	VMAX	P	IC maximum voltage
50	PLCD	P	LCD power supply
51-54	KEYOUT3-KEYOUT0	O	Keypad output
55-57	KEYIN2-KEYIN0	I	Keypad input
58-59	NC	-	Not connected
60	APO DIS	I	Auto power disable detection input (Active high)
61	AVDD	P	Analog positive power supply, 3V
62	PWR	O	Power control output
63	PWR_KEY	I	Power keypad sense input
64	AVSS	P	Analog negative power supply, ground
65	LBAT	I	Battery voltage detection input
66-68	NC	-	Not connected
69-70	SEG37-SEG36	O	LCD segment37-36 output
71	RX	I	Receive for UART input
72	TX	O	Transmit for UART output
73	SEG35	O	LCD segment35 output
74	NC	-	Not connected
75	$\overline{\text{RES}}$	I	External reset input
76	VDD	P	Positive power supply, 3V
77	VSS	P	Negative power supply, ground
78-80	SEG34-32	O	LCD segment35-33 output

ES168

Pin No	Symbol	Type	Description
1	CA2+	-	External capacitor connection for AC filter
2	CA2-	-	External capacitor connection for AC filter
3	RINT2	-	Integrator resistor connection
4	CINT2-	-	Integrator capacitor connection
5	CINT2+	-	Integrator capacitor connection
6	GNDA	P	Analog power ground
7	VR	I	Reference voltage input (-1.0V typical)
8	VRH	O	Bandgap voltage output (-1.23V typical)
9	VDDA	P	Analog positive power supply
10	VDDA	P	Analog positive power supply
11	NC	-	Not connected
12	OSC1	O	Oscillator input
13	OSC2	I	Oscillator output
14	VDDD	P	Digital positive power supply
15	BUZOUT	O	Buzzer driver output
16	DRDY	O	Data ready output
17	UB	O	Unbalance output
18	CEB	I	Chip enable input (Active @VSSD)
19	SCL	I	Serial bus clock
20	SDA	I/O	Serial bus data
21	IOCTL	-	MCU level shift
22	VCC	P	MCU power supply
23	GNDD	P	Digital power ground
24	GNDD	P	Digital power ground
25	VSSD	P	Digital negative power supply
26	NC	-	Not connected
27	VSSA	P	Analog negative power supply
28	VSSA	P	Analog negative power supply
29	NC	-	Not connected
30	NC	-	Not connected
31	GNDA	P	Analog power ground
32	CINT1+	-	Integration capacitor connection
33	CINT1-	-	Integration capacitor connection
34	RINT1	-	Integration resistor connection
35	NC	-	Not connected
36	CA1-	-	External capacitor connection for AC filter
37	CA1+	-	External capacitor connection for AC filter
38	VSRC	O	Source terminal for DUT
39	GNDA	P	Analog power ground
40	DTH	I	High sensed terminal for DUT
41	GNDA	P	Analog power ground
42	DTL	I	Low sensed terminal for DUT
43	GNDA	P	Analog power ground
44	SW1	O	Range ratio resistor1 (100Ω)
45	SW2	O	Range ratio resistor2 (1kΩ)
46	SW3	O	Range ratio resistor3 (10kΩ)
47	SW4	O	Range ratio resistor4 (100kΩ)
48	SW5	O	Range ratio resistor5 (1MΩ)

Absolute Maximum Ratings

Characteristic	Rating
Supply Voltage (VDD to VSS)	5V
Digital Input for ES168	VSSD -0.6 to GNDD + 0.6V
Digital Input for ES169	VSS -0.6 to VDD +0.6V
Power Dissipation. Flat Package	500mW
Operating Temperature	-20℃ to 70℃
Storage Temperature	-50℃ to 125℃

Electrical Characteristics

Table 1 Electrical characteristics

Parameter	Symbol	Test Condition	Min.	Typ.	Max	Units
3V Power supply	VDDD VDDA AVDD VDD		—	3	—	V
±3V Supply current VDDD/VDDA =3V VSSD/VSSA = -3V AVDDD/VDD = 3V	I_{DD}	Open	—	15	17	mA
DCR test signal level	V_{DUT}	Open/Short	—	1[1]/0.981	—	V
Testing signal amplitude (AC mode)	V_{DUT}	Open	—	1/0.5/0.25	—	V_{RMS}
Accuracy of testing signal amplitude (AC mode)	Ae	Open	—	—	±9	%
Accuracy of testing signal frequency	Ae	100-250kHz, Open	—	—	±0.12	%
Basic accuracy (F ≤ 10kHz) See Table 14 for details	Ae	10-100k Ω range	—	—	±0.2	%F.S[2,3]
Source Current (DC)	VSRC	VDDA = 3V, VSSA = -3V,	—		9.7	mA
Accuracy of DC bias level	Ae	1	—	—	±0.43	%
Temperature coefficient for basic accuracy (Ae)	Tc	-20℃<TA<70℃ ratio resistor=0ppm	—	—	100	ppm/℃
Band-gap reference voltage	V_{BG}	100KΩ resistor between VRH and VRL	-1.30	-1.22	-1.14	V
Peak-to-peak LCD drive voltage	V_{COM} V_{SEG}		—	3.0	—	V
Multi-level low battery detector	Vt1	VREF=3V V_{POWER_SENSE}	—	2.599	—	V
	Vt2		—	2.453	—	V
	Vt3		—	2.307	—	V
	Vt4		—	2.160	—	V

[1] Adjusting the VR to get a 1V DC output.
[2] Full scale: 20000 counts
[3] For best integral linearity of ADC, the metalized polypropylene film capacitor for CINT is necessary.

LCD bias voltage configuration			1/4 duty 1/3 bias A-type waveform			
Reference voltage input	V_{REF}	VR-VRL	-1010	-1000	-990	mV

TA=25℃

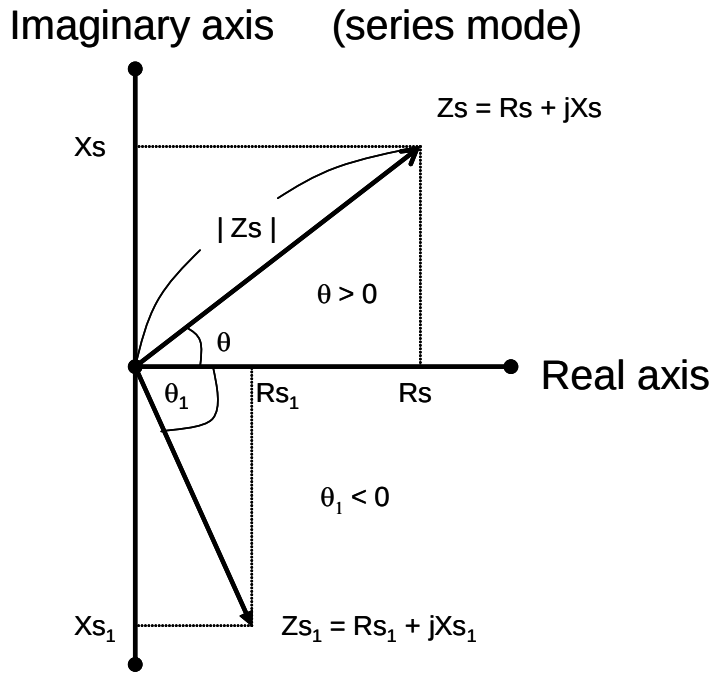
Impedance Measurement

Introduction

The ES169/ES168 chipset is a total solution for high accuracy LCR meter which could measure Inductance/Capacitance/Resistance with secondary parameters including dissipation factor(D), quality factor(Q), phase angle(θ), equivalent series/parallel resistance(ESR or Rp). The chipset is fully auto ranging operation for AC impedance & DC resistance measurement. Because of high integrated circuit design, a smart measurement for L/C/R is possible (AI mode). It means the user could measure the L/C/R components directly at AI smart mode without changing the function key. User could also select the target test frequencies of 100Hz/120Hz/1kHz/10kHz/100kHz depending on DUT type. Components could be measured in series or parallel mode according to the DUT impedance automatically.

The LCR chipset built-in a 4.5 digits ADC operates at 1.2/s updating rate nominally for L/C/R mode. The chipset operates at 0.5/s updating rate for DCR mode.

The general DMM could measure DC resistance only, but the LCR meter could measure DC resistance and AC impedance. The impedance consists of resistance (real part) and reactance (imaginary part). For example, Zs represents the impedance in series mode. Zs can be defined a combination of resistance Rs and reactance Xs. It also could be defined as a |Z| of magnitude with a phase angle θ.



Zs = Rs + jXs or |Zs|∠θ

$|Z| = \sqrt{Rs^2 + Xs^2}$

$Rs = |Zs| \cos\theta$

$Xs = |Zs| \sin\theta$

$Xs/Rs = \tan\theta$

$\theta = \tan^{-1}(Xs/Rs)$

If $\theta > 0$, the reactance is inductive. In other words, if $\theta < 0$, the reactance is capacitive.

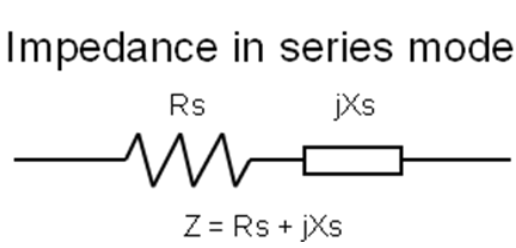
There are two types for reactance. The one is the inductive reactance X_L and the other is the capacitive reactance X_C. They could be defined as: (f = signal frequency)

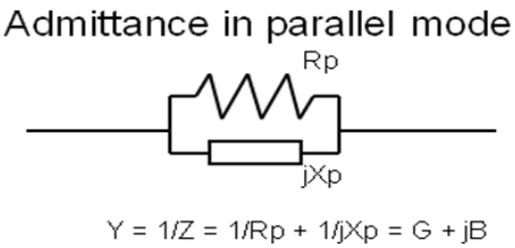
$X_L = 2\pi f L$ (L = Inductance)

$X_C = \frac{1}{2\pi f C}$ (C = Capacitance)

Measurement mode

The impedance could be measured in series or parallel mode. The impedance *Z* in parallel mode could be represented as reciprocal of admittance *Y*. The admittance could be defined as Y = G + jB. The G is the conductance and the B is the susceptance.





Rs: Resistance in series mode

Xs: Reactance in series mode

Cs: Capacitance in series mode

Ls: Inductance in series mode

Rp: Resistance in parallel mode

Xp: Reactance in parallel mode

Cp: Capacitance in parallel mode

Lp: Inductance in parallel mode

There are two factors to provide the ratio of real part and imaginary part. Usually the quality factor *Q* is used for inductance measurement and the dissipation factor *D* is used for capacitance measurement. *D* factor is defined as a reciprocal of *Q* factor.

$Q = 1 / D = \tan\theta$

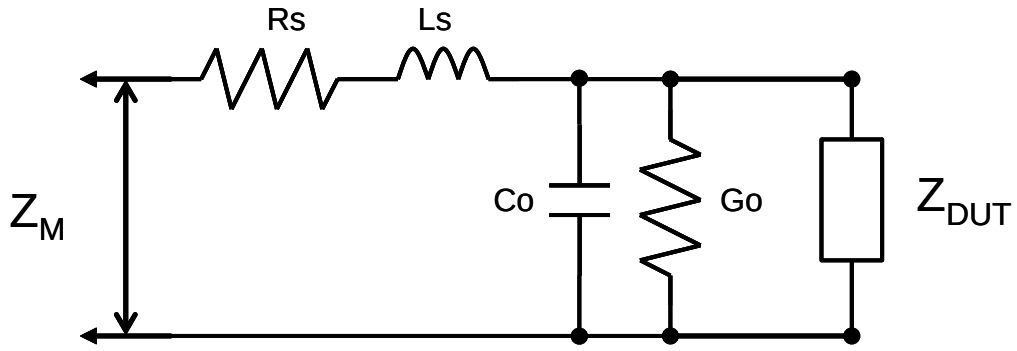
$Q = Xs / Rs = 2\pi f Ls / Rs = 1 / 2\pi f Cs\ Rs$

$Q = B / G = Rp / |Xp| = Rp / 2\pi f Lp = 2\pi f Cp\ Rp$

Actually, Rs and Rp are existed in the equivalent circuit of capacitor or inductor. If the capacitor is small, Rp is more important than Rs. If capacitor is large, the Rs is more important also. Therefore, use parallel mode to measure lower value capacitor and use series mode to measure higher value capacitor. For inductor, the impedance relationship is different from capacitor. If the inductor is small, Rp is almost no effect. If inductor is large, the Rs is no effect also. Therefore, use series mode to measure lower value inductor and use parallel mode to measure higher value inductor.

Open/short calibration

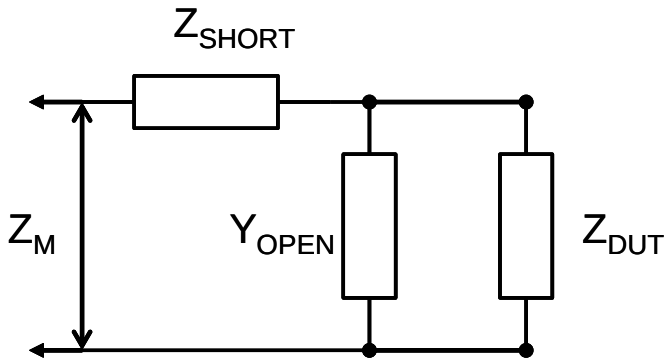
The ES169/ES168 chipset provides the open/short calibration process to get the better accuracy for high/low impedance measurement. The purpose of open/short calibration is to reduce the parasitic effect of the test fixture.



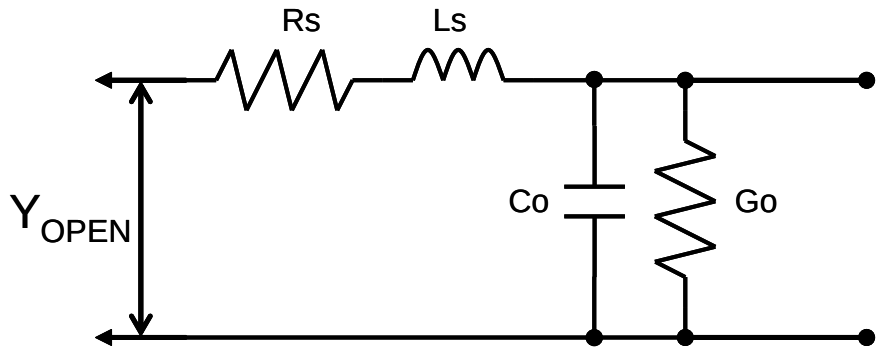
Z_M is defined as total impedance measured to DUT by the special test fixture which has some parasitic impedance. $Z_M = (Rs + j\omega Ls) + (\frac{1}{Go + j\omega Co} \parallel Z_{DUT})$

Z_{OUT} is the target impedance user wants to realize. It is necessary to use the open/short calibration process to cancel the effect of $Rs + j\omega Ls$ and $Go+j\omega Co$.

Equivalent circuit

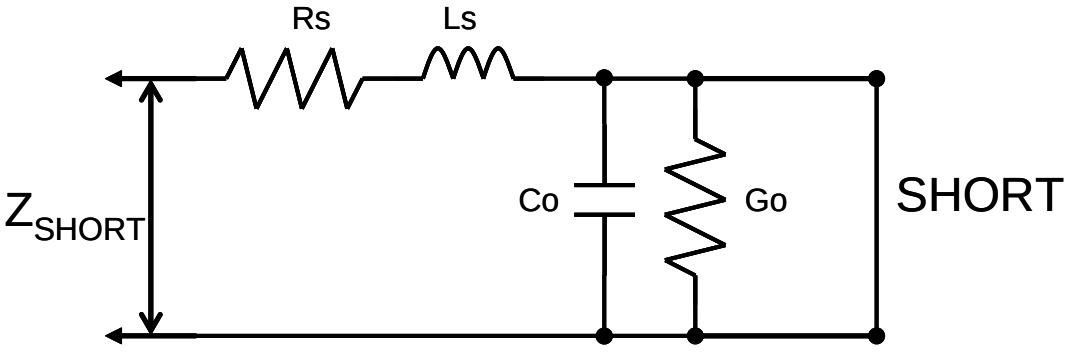


$$Z_{DUT} = \frac{Z_M - Z_{SHORT}}{1-(Z_M-Z_{SHORT})Y_{OPEN}}$$



If $Rs+j\omega Ls << 1/(Go + j\omega Co)$

$Y_{OPEN} = Go + j\omega Co$



$Z_{SHORT} = Rs + j\omega Ls$

KEYPADS Configuration

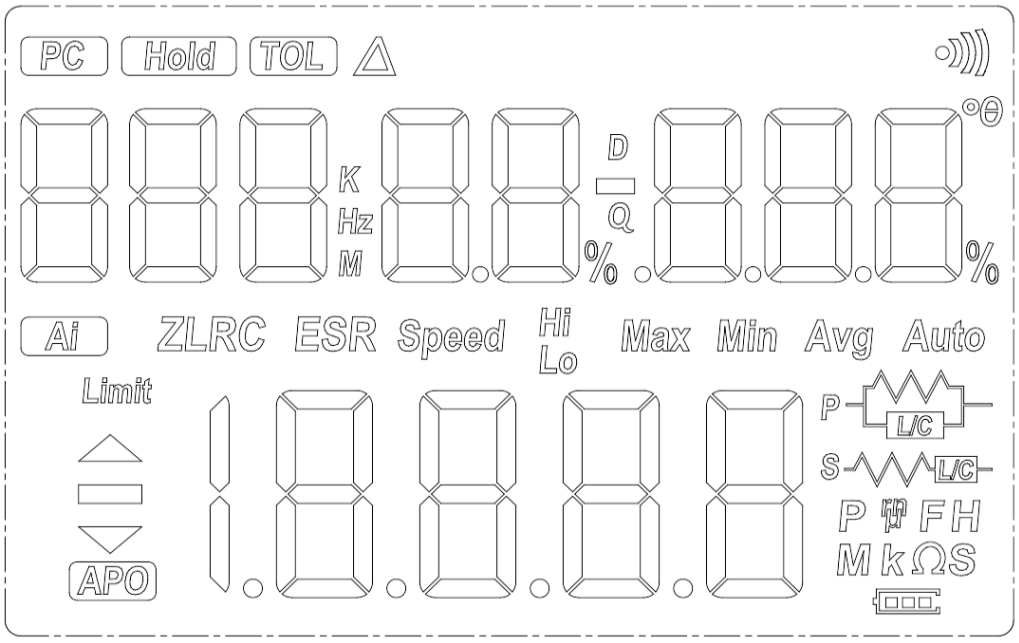
	KEYIN0	KEYIN1	KEYIN2
KEYOUT0	Ai/Setup	Freq Up/ESR ↑	HOLD/MMA .
KEYOUT1	DQθ/Limit ←	Freq Down/DCR ↓	Range/Auto →
KEYOUT2	ZLCR/PAL_SER	TOL%/BKLIT	REL/CAL

Table 2. Push key function description

Keypads	< 1 second	> 1 second
AI/ SETUP	Enable/disable the auto identification mode.	Enter/exit setup menu.
Freq Up / ESR	Select a test frequency. See table 11. Select a limit set in limit function.	Enable/disable the ESR (equivalent series resistance) mode.
HOLD/ MMA .	Enter/re-enter hold function. Selects Max., Min., Avg., and present reading in MMA function. Store parameters in setup mode.	Exit hold function. Enable/disable MMA function.
DQθ/ Limit	Switches between D, Q, and θ. Switches the upper/lower limit in limit function.	Enable/disable limit function.
Freq Down/ DCR	Selects a test frequency. See table 11. Selects a limit set in limit function.	Enable/disable DCR mode.
Range/ Auto	Disable auto range and sets a manual range. Switches the upper/lower limit in limit function.	Enables auto range
ZLRC/ PAL_SER	Switches between R, L, C, and Z. Cancel parameters changes or return to the measure mode in setup mode.	Toggles between parallel and series circuit mode. Enter POR setup menu during initialization, see to **Power ON/OFF**.
TOL%/ BKLIT	Enable the tolerance function or select a tolerance value.[4]	Enable/disable backlight.
REL/ CAL	Enable/disable relative function.	Enter/exit the user open/short calibration mode.

[4] Each key, excluding the Tol%/BKLIT key, can exit the tolerance mode.

OPERATION KEYPAD



1. Power ON/OFF

Power ON:

The system will power on when press POWER key. after power-up, the ES169 drives the PWR pin to high to keep the system powered.

The LCR powers up in the auto identification mode when first time turned on.

User can change the power-on measurement mode by changing internal parameters in POR setup mode. See Power-on setup (PON setup).

Power OFF:

The ES169 senses the POWER key. it drives the PWR pin low level to turn off the system power when press POWER key.

2. Auto Power Off

ES169 automatically drives the PWR pin to low to turn off the system after 5 minutes (default) if no keys are pressed. Pressing any key will reset the timer counter and keep system powered. An alarm will be issued before APO timer count approaches the APO set time.

3. Backlight driver

Press TOL%/BKLIT key for more than 1 second to toggle the BL (pin32 of ES169) to output high/low level. The BL will output low automatically, when the backlight timer counter reaches the backlight set time.

4. Battery detection

The ES169 will detect the battery multi-level voltages periodically. The LCD annunciators (BAT4 ~ BAT1) of battery life will be disappeared according to the decreasing of battery voltage.

5. LCD test

Press Hold/MMA key for more than 1 second during power up to test the LCD. All annunciators are displayed in the LCD. Press Hold/MMA key again to exit this mode.

6. Manual range/ auto range

In auto ranging, the ES169 automatically selects an appropriate range to display the highest available precision. Press Range/Auto key to switch the manual range mode.

In manual, user can cycle through the Range/Auto key to select the range he wants. Press Range/Auto key for more than 1 seconds to switch the auto range mode.

7. Hold

Press the Hold/MMA key to freeze the display for any measurement mode. The Hold annunciator will show on the display while the Hold mode. Press the Hold/MMA key again will update a new reading on the display. Press the Hold/MMA key for more than 1 seconds to exit Hold mode.

8. Maximum, Minimum and Average

Press the Hold/MMA key for more than 1 seconds to enter MMA mode while any measurement mode.

In MMA mode[8]

Press the Hold/MMA key again to cycle through follow display mode:

- Max: the maximum reading[5].
- Min: the minimum reading[6].

[5] It will not update the maximum value if display value is OL.

- Avg: the average reading.
- MaxMinAvg: the current reading.

Press the Hold/MMA key for more than 1 seconds to exit MMA mode.

9. Sorting by tolerance mode

The tolerance ranges available are 1%, 5%, 10% and 20%.

To enable the tolerance mode:

- Inset a component into the input, then press the TOL%/BKLIT key to set the reading value[7] as the standard reference tolerance.
- In Hold mode or MMA mode, press the TOL%/BKLIT key to set the display value[7] as the standard reference tolerance.

In tolerance mode[8]:

- The standard reference value is shown on the primary display.
- Press TOL%/BKLIT to cycle through 1%, 5%, 10% and 20% tolerance.
- Replace a component to start a new sorting.
- It will beep three times if the component exceeds the set reference, otherwise, when it beeps once, it indicates that the component is within the set tolerance.
- The tolerance error is shown as percentage on the secondary display.
- Press any key to exit tolerance mode exclude TOL%/BKLIT key.

10. Sorting by limit function

User can use upper and lower limits for sorting. There are thirty-two limit set available.

To enable the limit function:

- Press the DQθ/Limit key for more than 1 second to enter limit function while any measurement mode.
- While the Limit annunciator is flashing, use the Freq Up/ESR or Freq Down/DCR to select an appropriate limit set.
- Press the DQθ/Limit or Range/Auto to toggle between the upper or lower values shown on the primary display.
- Press Hold/MMA to start sorting when the Limit annunciator flashing. (If no key is pressed, sorting will also begin after 3 seconds.)

Limit function is enabled:

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[6] It will not update the minimum value if display is less than 50 counts.
[7] The tolerance mode cannot be activated if display value is OL or less than 50 counts.
[8] It will automatically switch to manual range if it is in auto range.

- Insert component into input, the ES169 drive beeper to make three beeps and display nGo on the secondary display if the reading is greater ▲ than the upper limit or lesser ▼ than the lower limit.
- Insert component into input, the ES169 drive beeper to make once beep and display Go on the secondary display if the reading is within upper limit and lower limit.
- Press the DQθ/Limit key for more than 1 second to disable limit function.

11. Relative function

The reading value is the difference between the input value and the stored value.

To enable the relative function:

- The present display value[9] is stored as stored value when the Rel/Cal key is pressed while measurement mode.

Relative function is enabled:

- The △ annunciator is shown on the display.
- Press Rel/Cal key to disable relative function.

12. Auto identification function

The Ai function helps to identify R, L, and C measurements automatically according to the angle of impedance detected from input. See Table 3.

To enable the auto identification function:

- Press Ai/Setup to start auto identification function.

When auto identification function is enabled:

- Selects an appropriate measurement for input.
- Selects an appropriate range.
- Selects parallel or series mode automatically.

Table 3. auto identification phase angle rule

Phase angle	Primary display	Secondary display
$-\theta_{set} < \theta < +\theta_{set}$[10]	R	θ
$\theta \geq +\theta_{set}$	L	Q
$\theta \leq -\theta_{set}$	C	D

[9] The relative mode cannot be activated if the display value is OL.

[10] The default θ_{set} is set to 10° .

13. Dissipation factor/ quality factor/ phase angle (D/Q/θ)

Press DQθ/Limit key to cycle through dissipation factor, quality factor, and phase angle while resistance, inductance, capacitance, or impedance measurement mode. This setting is not application for DCR and ESR measurement.

14. Resistance, inductance, capacitance, and impedance measurement

i. Press the Freq Down/DCR or Freq Up/ESR to select a suitable test frequency.
ii. Press the ZLCR/Pal_Ser key to cycle through resistance, inductance, capacitance and impedance measurement mode.
iii. Press the Ai/Setup to enable the auto identification function.
iv. Insert a component into the input.
v. Read the displays.

15. Parallel/Series circuit mode (P/S)

Press the ZLCR/Pal_Ser key for more than 1 second to toggle parallel or series mode. In auto identification mode, it switches to parallel mode automatically if impedance is greater than 10kΩ or switched to series mode automatically if impedance is lower than 10kΩ.

16. DC bias

Use the DC bias to turn on the active components for measurement.

To enable DC bias:

i. Press the Ai/Setup for more than 1 second to enter setup menu.
ii. Press the DQθ/Limit or Range/Auto key to switch to DC menu.
iii. Press the Freq Up/ESR or Freq Down/DCR key to select DC bias level[11,13].
iv. Press the Hold/Rec to confirm changes or press ZLCR/Pal_Ser to exit setup menu.

Table 4. DC bias

	LEVEL
DC bias	0V
	1V

[11] The DC bias level available are $0V_{DC}$, and $1V_{DC}$.

17. Test signal amplitude

Select an appropriate test signal amplitude to measure the component.

To change the test signal amplitude:

i. Press the Ai/Setup for more than 1 second to enter setup menu.
ii. Press the DQθ/Limit or Range/Auto key to switch to AC menu.
iii. Press the Freq Up/ESR or Freq Down/DCR key to select test signal amplitude[12,13].
iv. Press the Hold/Rec to confirm changes or press ZLCR/Pal_Ser to exit setup menu.

Table 5. Test signal amplitude

	Amplitude (RMS)
Test signal amplitude	1V
	0.5V
	0.25V

18. ESR measurement

Use the ESR measurement to measure the equivalent series resistance.

To enable ESR measurement:

- Press Freq Up/ESR for more than 1 second to start ESR measurement.

When ESR measurement is enabled:

- Select a suitable test frequency.
- Press Freq Up/ESR for more than 1 second to exit ESR measurement.

19. DCR measurement

Use the DCR measurement to measure the resistance of component by 1VDC.

To enable DCR measurement:

- Press Freq Down/DCR for more than 1 second to start DCR measurement.

When ESR measurement is enabled:

- Press Freq Down/DCR for more than 1 second to exit DCR measurement.

[12] The amplitude available are 1000m, 500m, and 250mV_{RMS}.
[13] The peak value of the test signal does not exceed 2.5V, including DC bias and AC amplitude.

20. Test frequency select

Press Freq Up key and Freq Down key to select the test frequency.(See **Table 10**.)

Table 6. resistance display range with frequency

Function	Frequency	Scale Range	Resolution
R_S/R_P	100Hz	200.00Ω	0.01Ω
		2.0000kΩ	0.1Ω
		20.000kΩ	1Ω
		200.00kΩ	0.01kΩ
		2.0000MΩ	0.1kΩ
		20.00MΩ	1kΩ
	1kHz	20.000Ω	1mΩ
		200.00Ω	0.01Ω
		2.0000kΩ	0.1Ω
		20.000kΩ	1Ω
		200.00kΩ	0.01kΩ
		2.0000MΩ	0.1kΩ
		20.00MΩ	1kΩ
	10kHz	20.000Ω	1mΩ
		200.00Ω	0.01Ω
		2.0000kΩ	0.1Ω
		20.000kΩ	1Ω
		200.00kΩ	0.01kΩ
		2.0000MΩ	0.1kΩ
		20.00MΩ	0.01MΩ
	100kHz/200kHz/250kHz	20.000Ω	1mΩ
		200.00Ω	0.01Ω
		2.0000kΩ	0.1Ω
		20.000kΩ	1Ω
		200.00kΩ	0.01kΩ
		2.000MΩ	1kΩ

Table 7. DC resistance display range

Function	Scale Range	Resolution
DCR	200.00Ω	0.01Ω
	2.0000kΩ	0.1Ω
	20.000kΩ	1Ω
	200.00kΩ	0.01kΩ
	2.0000MΩ	0.1kΩ
	20.00MΩ	1kΩ

Table 8. Capacitance display range with frequency

Function	Frequency	Scale Range	Resolution
C_S/C_P	100Hz	20.000nF	1pF
		200.00nF	0.01nF
		2000.0nF	0.1nF
		20.000uF	1nF
		200.00uF	0.01uF
		2000.0uF	0.1uF
		20.00mF	0.01mF
	1kHz	2.0000nF	0.1pF
		20.000nF	1pF
		200.00nF	0.01nF
		2000.0nF	0.1nF
		20.000uF	1nF
		200.00uF	0.01uF
		2.000mF	1uF
	10kHz	200.00pF	0.01pF
		2000.0pF	0.1pF
		20.000nF	1pF
		200.00nF	0.01nF
		2000.0nF	0.1nF
		20.000uF	1nF
		200.0uF	0.1uF
	100kHz/200kHz/250kHz	200.00pF	0.01pF
		2000.0pF	0.1pF
		20.000nF	1pF
		200.00nF	0.01nF
		2000.0nF	0.1nF
		20.00uF	0.01uF

Table 9. Inductance display range with frequency.

Function	Frequency	Scale Range	Resolution
L_S/L_P	100Hz	20.000mH	1uH
		200.00mH	0.01mH
		2000.0mH	0.1mH
		20.000H	1mH
		200.00H	0.01H
		2000.0H	0.1H
		20.000kH	0.001kH
	1kHz	2.0000mH	0.1uH
		20.000mH	1uH
		200.00mH	0.01mH
		2000.0mH	0.1mH
		20.000H	1mH
		200.00H	0.01H
		2.0000kH	0.1H
	10kHz	200.00uH	0.01uH
		2000.0uH	0.1uH
		20.000mH	1uH
		200.00mH	0.01mH
		2000.0mH	0.1mH
		20.000H	1mH
	100kHz/200kHz/250kHz	20.000uH	0.001uH
		200.00uH	0.01uH
		2000.0uH	0.1uH
		20.000mH	1uH
		200.00mH	0.01mH

Table 10. frequency tuning

Tuning value	Frequency			
1.5	150Hz	—	15kHz	150kHz
1.2	120Hz	—	12kHz	120kHz
1.0	100Hz	1kHz	10kHz	100kHz
0.8	—	800Hz	8kHz	80kHz
0.6	—	600Hz	6kHz	60kHz
0.5	—	500Hz	5kHz	50kHz
0.4	—	400Hz	4kHz	40kHz
0.3	—	300Hz	3kHz	30kHz
0.25	—	250Hz	—	25kHz
0.2	—	200Hz	2kHz	20kHz

21. Calibration function

The Calibration function corrects the system internal parameters as well as external connector residues for precision measurement. It is recommended to do open/short calibration before measurement.

i. Press Rel/Cal key for more than 1 second to enter calibration menu.
ii. Press Freq Up/ESR or Freq Down/DCR to switch open or short calibration.
iii. Press Hold/Rec to start calibration.
iv. Press Rel/Cal key for more than 1 second to exit calibration menu.

The CAL annunciator is shown on secondary display and flash during the calibration process. After the open/short calibration is completed, the CAL annunciator is constantly shown on secondary display and the ES169 will store the calibration data in its ROM memory.

The open/short annunciator is constantly shown on primary display during the calibration process. If the input is out of tolerance, the open/short annunciator will flash.

22. Power-on setup (PON setup)

The setup menu allows user to change the default value for several functions.

Table 11. PON setup menu key function

Keypad	Description
ZLCR/Pal_Ser	Press and hold ZLCR/Pal_Ser while turning the system ON to enter PON setup menu. While the menu item is flashing, press ZLCR/Pal_Ser to cancel the changes.
DQθ/Limit, Range/Auto	Press DQθ/Limit or Range/Auto to setup through the menu items.
Freq Up/ESR, Freq Down/DCR	Press Freq Up/ESR or Freq Down/DCR to enter the item menu. Press Freq Up/ESR or Freq Down/DCR again to change the item value. Press Freq Up/ESR or Freq Down/DCR for more than 1 second to increase/ decrease a numerical value faster.
HOLD/MMA .	While the menu item is flashing, press HOLD/MMA to save the changes.

Table 12. menu items

Parameter	Value	Default value
Measurement type	Ai, Z, L, R, C, ESR and DCR	Ai
Testing signal frequency	100Hz, 1kHz, 10kHz, 100kHz, 200kHz, 250kHz	1kHz
Z	D, Q, or θ Parallel or series	θ Series
L	D, Q, or θ Parallel or series	Q Series
R	D, Q, or θ Parallel or series	θ Series
C	D, Q, or θ Parallel or series	D Parallel
Ai (θ)	5°~45°	10°
Calibration (open/short)	Factory or user	Factory
Limit	Factory or user 00~15	Factor 00
Limit (upper or lower)	0-19999	See Table 13
Uart (baud rate)	9600 or 19200	9600
Uart (parity)	Even, odd or none	None
Uart (data bits)	7 bits or 8 bits	7 bits
Beep frequency	1k, 1.33k, 2k, 2.22k, 2.667k, 3.080k, 3.333k, 4kHz	1kHz
Lock keypad	OFF or ON	OFF
APO	OFF – 99 minutes	5 minutes
Backlight	OFF – 99 seconds	30 seconds
Reset	Reset to factory value	

Table 13. Limit set

Set	Upper limit (H)	Lower limit (L)
00	1000	900
01	1200	1080
02	1500	1350
03	1800	1620
04	2200	1980
05	2700	2430
06	3300	2970
07	3900	3510
08	4700	4230
09	5600	5040
10	6800	6120
11	8200	7380
12	10000	9000
13	12000	10800
14	15000	13500
15	18000	16200

Accuracy (Ae) vs. Impedance (Z_{DUT})

Table 14. Accuracy (Ae) vs. Impedance (Z_{DUT}) @ Ta =18 ~ 28 ℃, 1.0 / 0.5V_{RMS}

Z / Freq.	1Ω ~0.1Ω[14]	10Ω ~1Ω[14]	100KΩ ~10Ω	1MΩ ~100KΩ	10MΩ ~1MΩ	Remark
DCR	1.0%+5d	0.5%+3d	0.3%+2d	0.5%+3d	1.0%+5d	
100Hz	1.0%+5d	0.5%+3d	0.3%+2d	0.5%+3d	2%+5d	
1kHz	1.0%+5d	0.5%+3d	0.3%+2d	0.5%+3d	2%+5d	
10kHz	1.0%+5d	0.5%+3d	0.3%+2d	0.7%+3d	2%+5d	D<0.1
100kHz	2.0%+5d	1.0%+5d	0.5%+3d	1%+5d		
200kHz	2.0%+5d	1.0%+5d	0.5%+3d	3%+5d		
250kHz	2.0%+5d	1.0%+5d	0.6%+3d	4%+5d		

Note: All accuracy is guaranteed by proper ratio resistor calibration and open/short calibration. All accuracy is guaranteed for 10cm distance from VDUTH/VDUTL pins of ES168.

The higher the DC bias level or the lower the testing signal amplitude, the worse the accuracy.

If D > 0.1, the accuracy should be multiplied by $\sqrt{1+D^2}$

$Z_C = 1/2\pi f C$ if D << 0.1 in capacitance mode

$Z_L = 2\pi f L$ if D << 0.1 in inductance mode

Sub-display parameters accuracy

Ae = impedance (Z) accuracy

Definition: Q = $1/D$

$$Rp = ESR \text{ (or Rs)} \times (1+ 1/D^2)$$

1. D value accuracy De = $\pm$ Ae × (1+D)
2. ESR accuracy Re= $\pm$ Z_M × Ae (Ω)

   ie., Z_M = impedance calculated by $1/2\pi fC$ or $2\pi f L$
3. Phase angle θ accuracy θe= $\pm$ (180/π) × Ae (deg)

[14] The accuracy does not apply to measure 0.1Ω to 10Ω when DC bias is added. The error increased by more than 1%.

4-terminals measurement with guard shielding

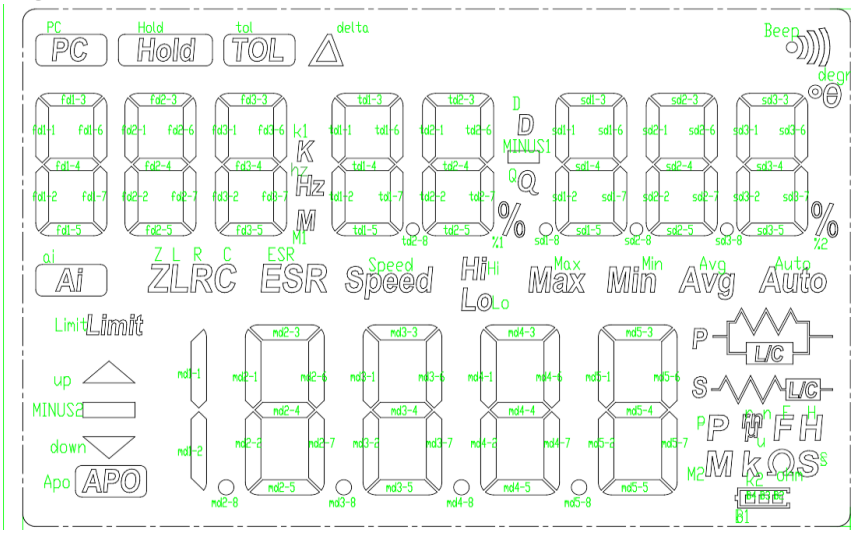
The DUT test leads are implemented by four terminals measurement. For achieve the accuracy shown above, it is necessary to do open/short calibration process before measurement. The test leads for DUT should be as short as possible. If long extended cable is used, the guard shielding is necessary.

LCD Truth table

Table 15. LCD truth table

LCD Segment	COM1	COM2	COM3	COM4
SEG01	delta	tol	hold	pc
SEG02	fd1-3	fd1-1	fd1-2	ai
SEG03	fd1-6	fd1-4	fd1-7	fd1-5
SEG04	fd2-3	fd2-1	fd2-2	Z
SEG05	fd2-6	fd2-4	fd2-7	fd2-5
SEG06	fd3-3	fd3-1	fd3-2	L
SEG07	fd3-6	fd3-4	fd3-7	fd3-5
SEG08	k1	hz	M1	R
SEG09	td1-3	td1-1	td1-2	C
SEG10	td1-6	td1-4	td1-7	td1-5
SEG11	td2-3	td2-1	td2-2	td2-8
SEG12	td2-6	td2-4	td2-7	td2-5
SEG13	D	MINUS1	Q	%1
SEG14	sd1-3	sd1-1	sd1-2	sd1-8
SEG15	sd1-6	sd1-4	sd1-7	sd1-5
SEG16	sd2-3	sd2-1	sd2-2	sd2-8
SEG17	sd2-6	sd2-4	sd2-7	sd2-5
SEG18	sd3-3	sd3-1	sd3-2	sd3-8
SEG19	sd3-6	sd3-4	sd3-7	sd3-5
SEG20	BEEP	degree	%2	
SEG21				ESR
SEG22	AVG	MIN	MAX	
SEG23	AUTO	Parallel (P)	Series (S)	
SEG24	B1	B2	B3	B4
SEG25	H	F	S	OHM
SEG26		n(m)	u	k2
SEG27		r(m)	P	M2
SEG28	md5-6	md5-4	md5-7	md5-5
SEG29	md5-3	md5-1	md5-2	md5-8
SEG30	md4-6	md4-4	md4-7	md4-5
SEG31	md4-3	md4-1	md4-2	md4-8
SEG32	md3-6	md3-4	md3-7	md3-5
SEG33	md3-3	md3-1	md3-2	md3-8
SEG34	md2-6	md2-4	md2-7	md2-5
SEG35	md2-3	md2-1	md2-2	md2-8
SEG36		md1-1	md1-2	apo
SEG37	Limit	up	MINUS2	down

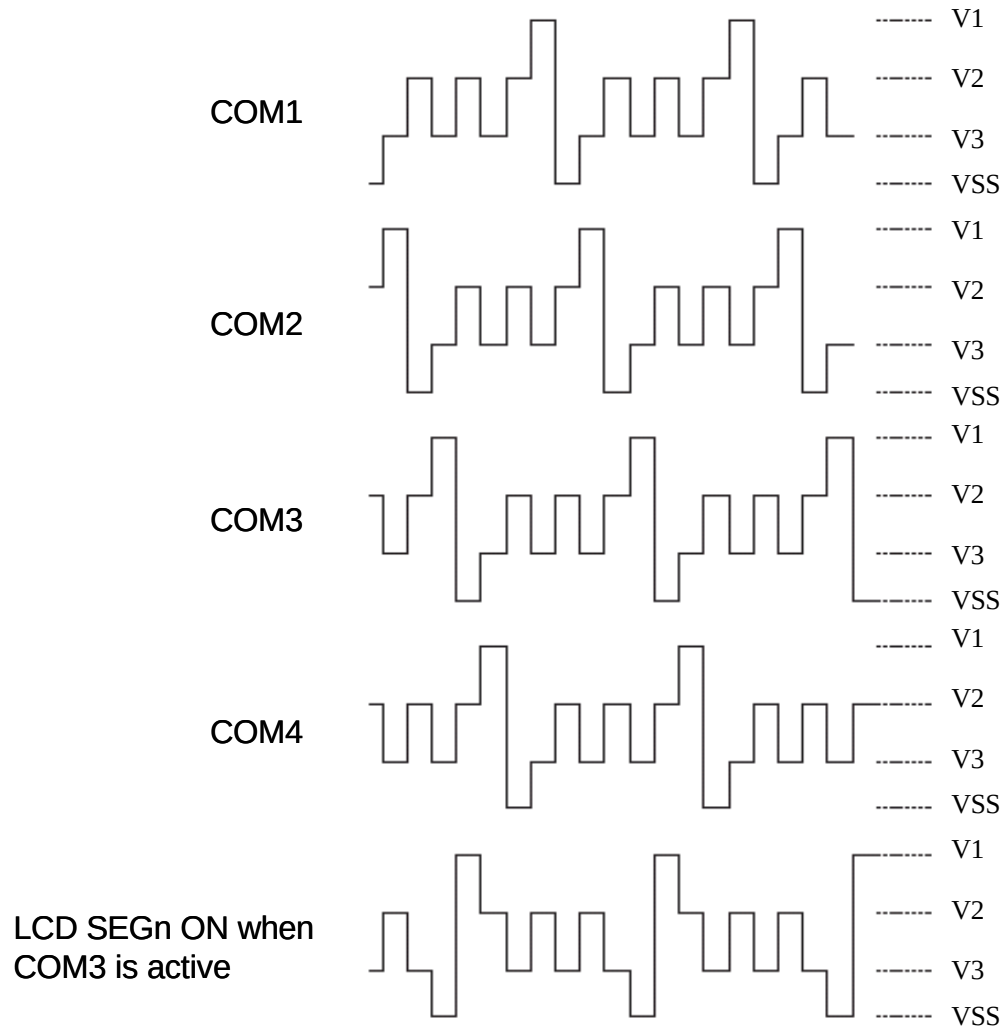
LCD configuration



LCD display active condition

LCD annunciates	Condition
PC	Remote access indicator
Hold	HOLD function is enabled
Tol	Tolerance function is enabled
Delta	Relative function is enabled
fdm-n	Testing frequency or DCR display
K1, M1, Hz	Units for testing frequency
tdm-n	Tolerance display
%1	Units for Tolerance
D	Dissipation factor indicator
Q	Quality factor indicator
θ	Phase angle of impedance indicator
%2	Measurement units for tolerance
MINUS1, sdm-n	Secondary display
Beep	Alert indicator for sorting
Ai	Auto identification function is enabled
Z	Impedance measurement indicator
L	Inductance measurement indicator
R	Resistance measurement indicator
C	Capacitance measurement indicator
ESR	ESR measurement indicator
Max, Min, Avg	MMA function is enabled
Auto	Auto range function is enabled
Limit	Limit for sorting indicator
up	Reading out of upper limit
Down	Reading out of lower limit
APO	Auto power-off indicator
MINUS2, mdm-n	Primary display
Parallel (P)	Parallel mode indicator
Series (S)	Series mode indicator
p, u, m, k, M, F, H, ohm, S	Measurement units for primary display
B1, B2, B3, B4	Battery voltage indicator

LCD COM/SEG driver output



1/4 duty 1/3 bias
frame rate 62.5Hz

UART Interface

Baud rate	9600/19200 bps
Start bit	1 bit
Data bits	7/8 bits
Stop bit	1 bit
Parity	none/ odd/ even

User can access the system through UART interface. The system receives the command, it enters remote function and PC annunciator is shown on display. The system sends impedance readings via the UART when it receives “READ?” command. Press any key to exit remote function.

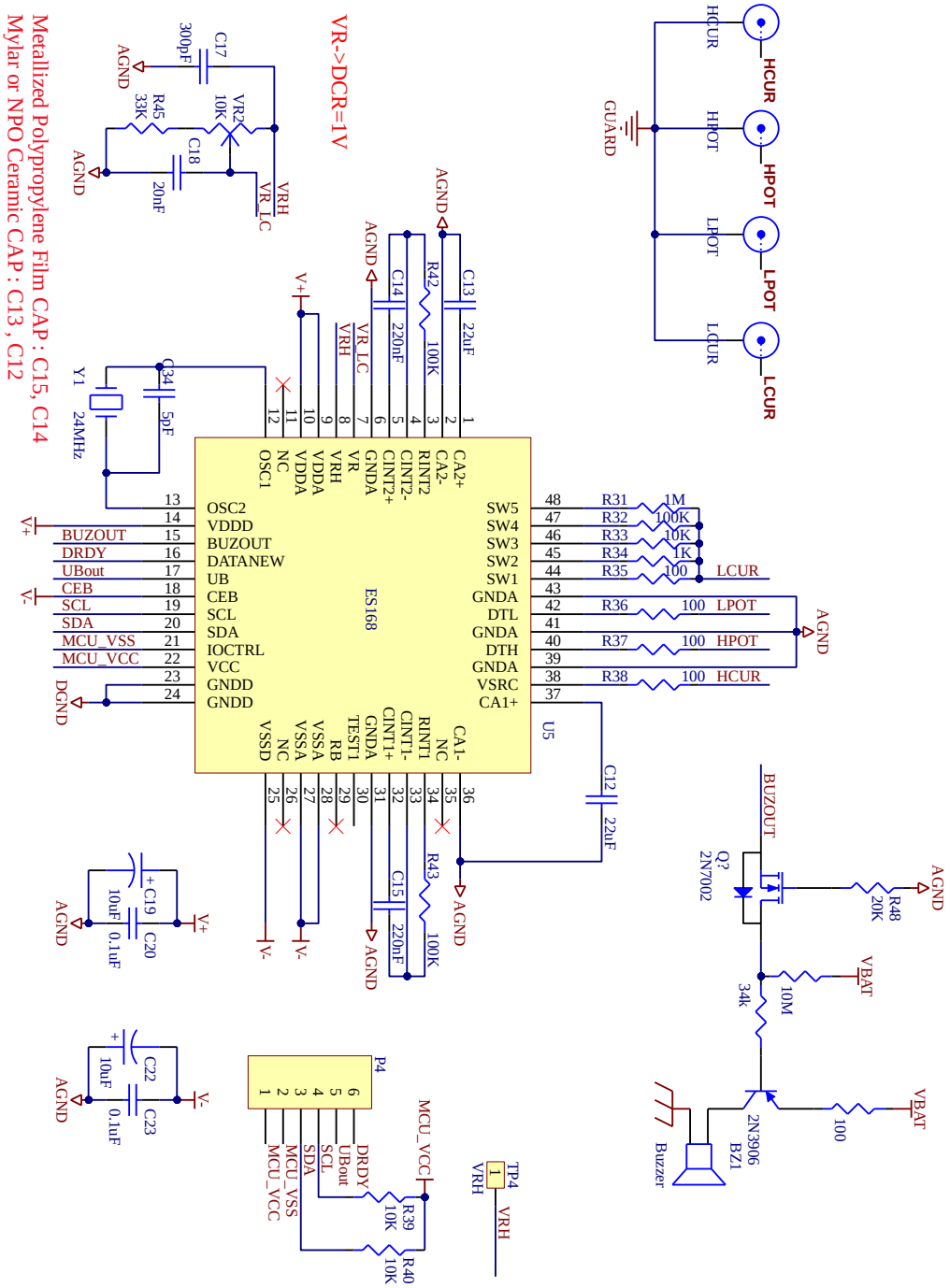
Table 16. command table

Change testing signal frequency	
Command	<value> Hz
Response	OK
Example: “10kHz;”. When the command is received, the system changes the test signal frequency to 10 kHz.	
Change measurement type	
Command	TYPE {<value>| Ai | ESR | R | L | C | Z |}, {<mode>| PARALLE | SERIES |}
Response	OK
Example: “TYPE R, SERIES”. When the command is received, the system changes the measurement type to resistance measurement and series mode.	
Change testing signal amplitude	
Command	AC {<value>| 1 | 0.5 | 0.25 |}
Response	OK
Example: “AC 1”. When the command is received, the system changes the test signal amplitude to 1VRMS.	
Change DC bias level	
Command	DC {<value>| 0 | 1 |}
Response	OK
Example: “DC 1”. When the command is received, the system changes DC bias to $1V_{DC}$.	
Change conversion rate	
Command	INT {<value>| 0 | 1 | 2 |}
Response	OK
Example: “INT 1”. When the command is received, the system will change the conversion rate to 200 milliseconds.	
Read impedance value and primary display value	
Command	READ?
Response	See Table 17
Example: “READ?”. When the command is received, the system continuously send read value to PC.	

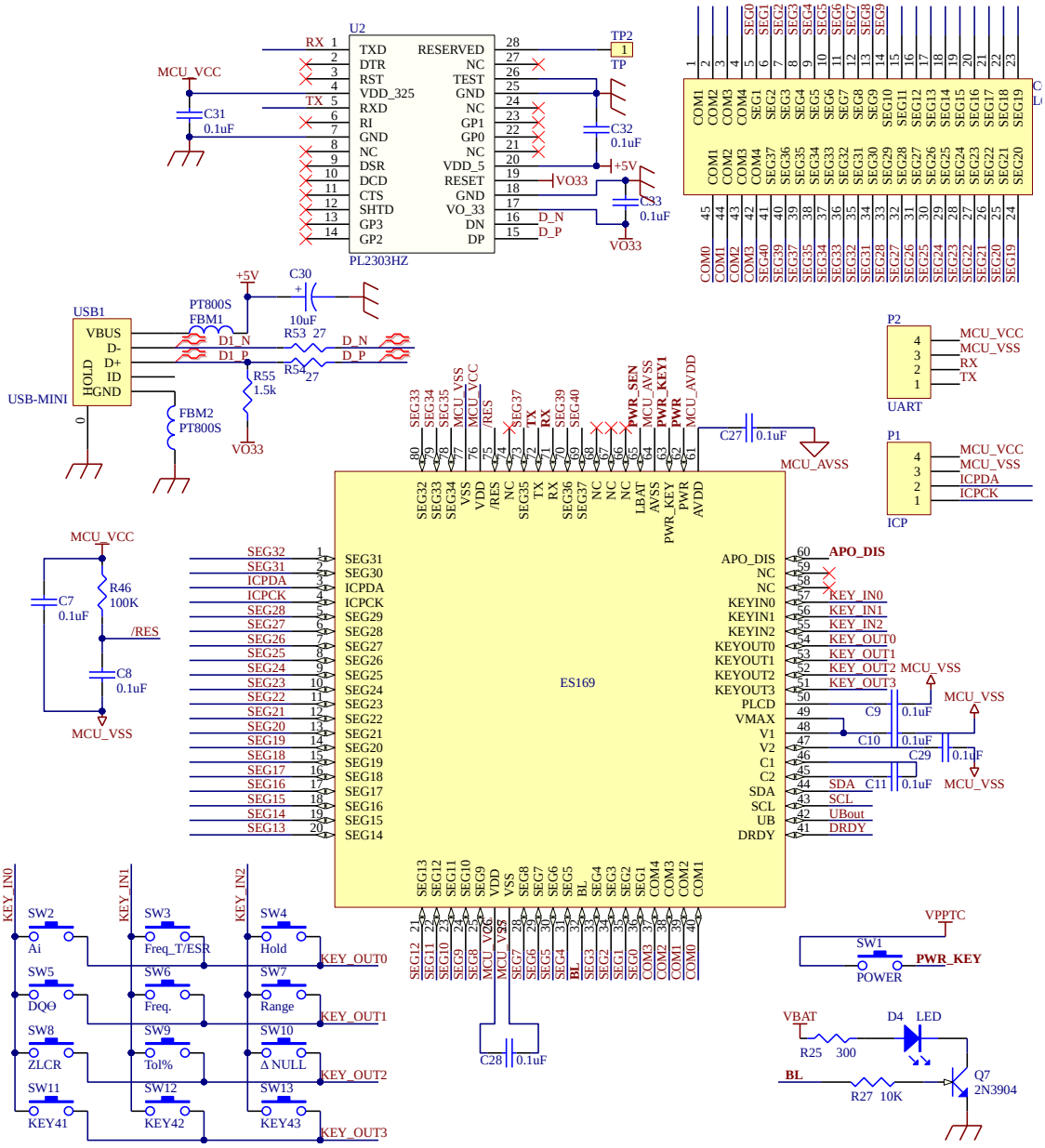
Table 17. read command response

Frequency	Parallel/Series	R/L/C/Z/DCR/ESR	R+Xj
Frequency		Freq:<value>	
Parallel or series mode		<parallel, series>	
R/L/C/Z/DCR/ESR		Current measurement mode indication	
R +Xj		Real part and imaginary part	

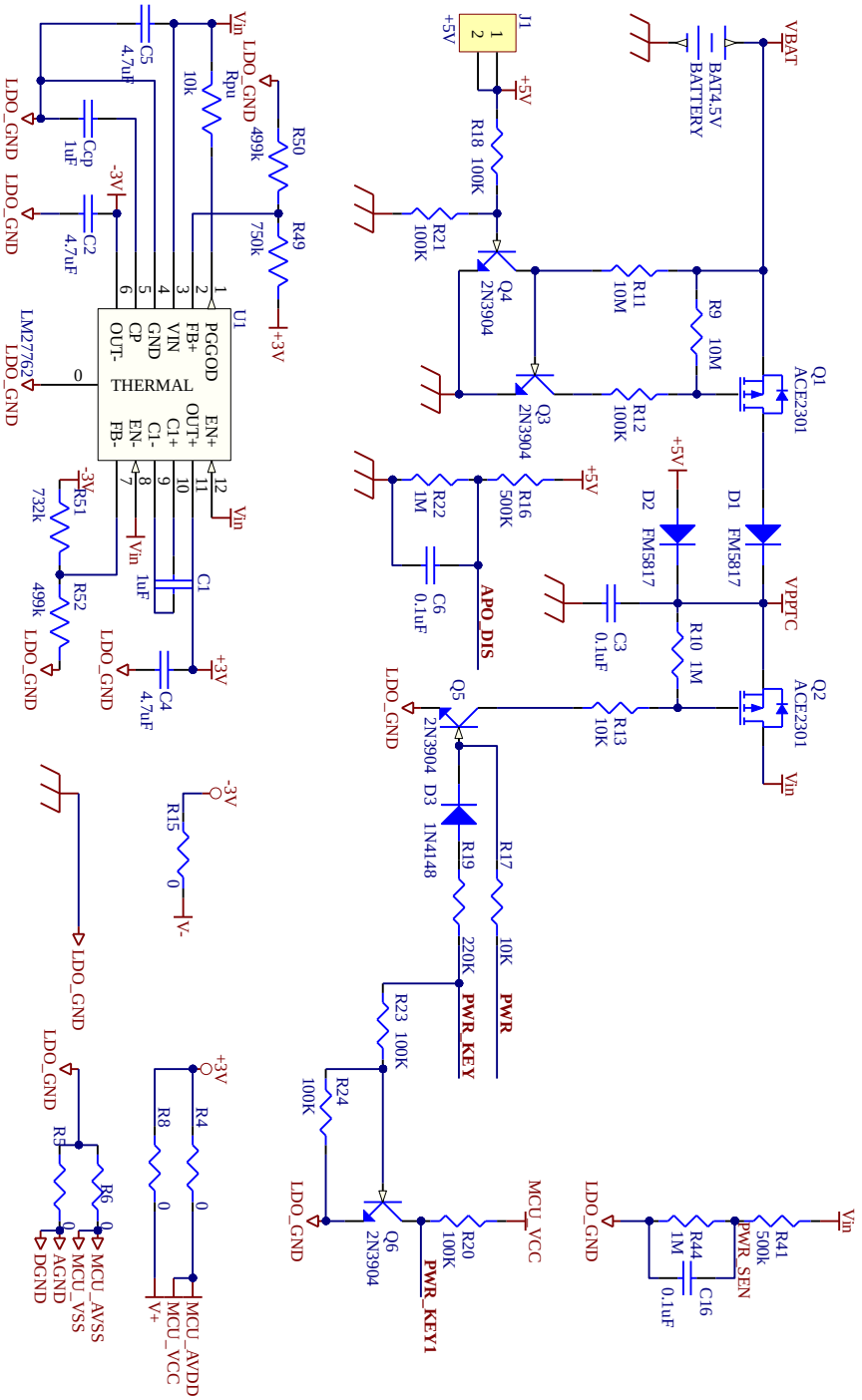
Application circuit



ES168 Circuit

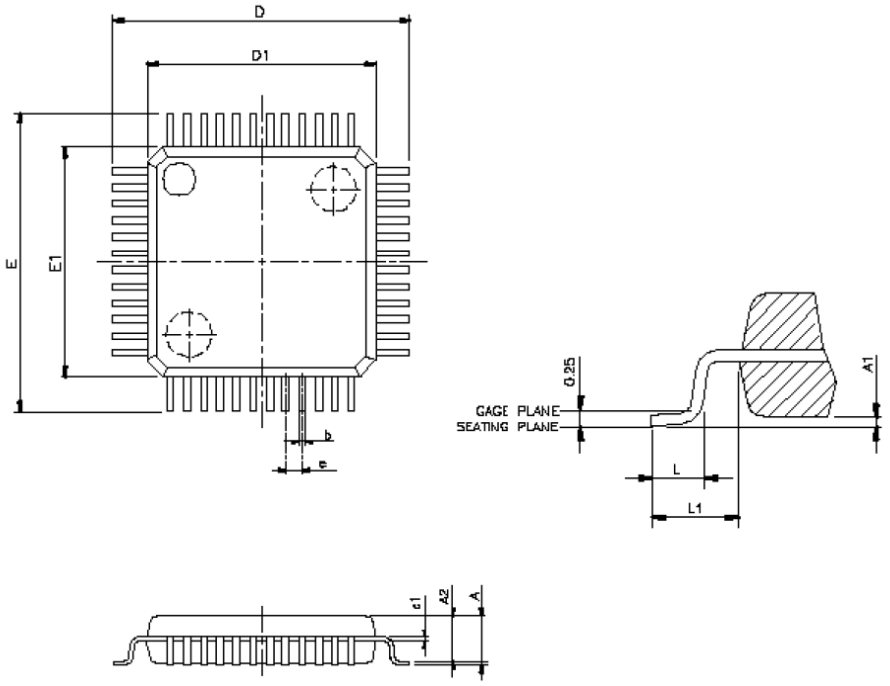


ES169 Circuit



Power circuit

Package information (LQFP-48 7x7)



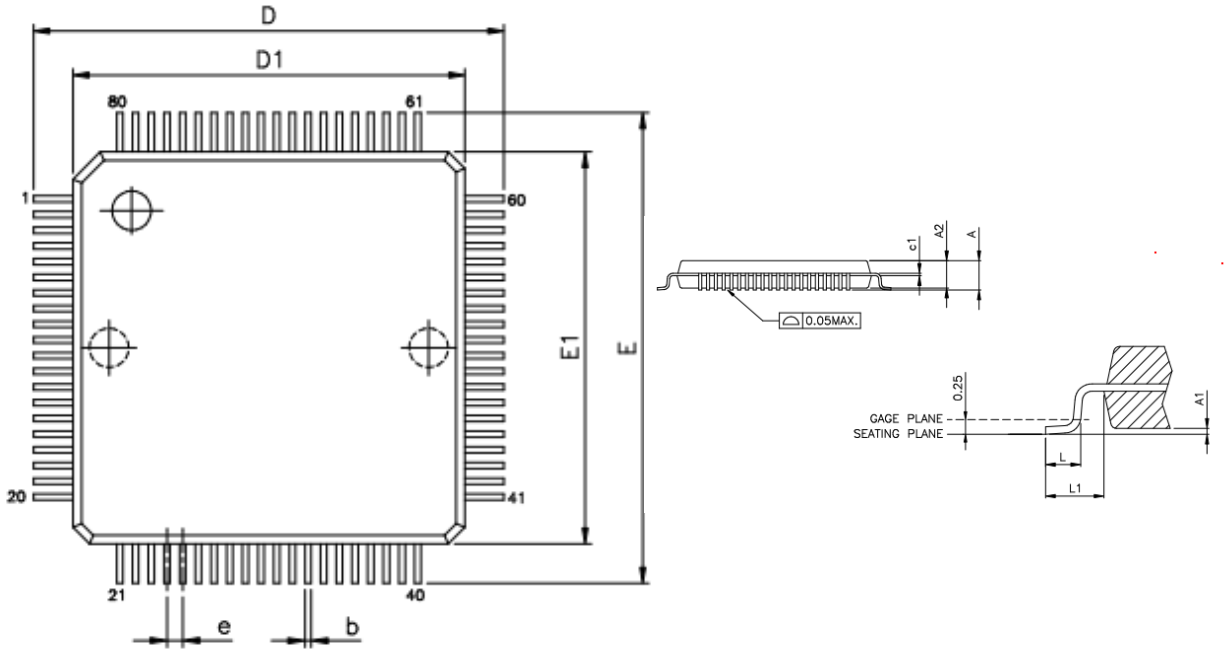
VARIATIONS (ALL DIMENSIONS SHOWN IN MM)

SYMBOLS	MIN.	MAX.
A	--	1.6
A1	0.05	0.15
A2	1.35	1.45
c1	0.09	0.16
D	9.00 BSC	
D1	7.00 BSC	
E	9.00 BSC	
E1	7.00 BSC	
e	0.5 BSC	
b	0.17	0.27
L	0.45	0.75
L1	1 REF	

NOTES:

1. JEDEC OUTLINE: MS-026 BBC
2. DIMENSIONS D1 AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.25mm PER SIDE. D1 AND E1 ARE MAXIMUM PLASTIC BODY SIZE DIMENSIONS INCLUDING MOLD MISMATCH.
3. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL NOT CAUSE THE LEAD WIDTH TO EXCEED THE MAXIMUM b DIMENSION BY MORE THAN 0.08mm.

Package information (LQFP-80)



VARIATIONS (ALL DIMENSIONS SHOWN IN MM)

SYMBOLS	MIN.	MAX.
A	--	1.6
A1	0.05	0.15
A2	1.35	1.45
c1	0.09	0.16
D	12 BSC	
D1	10 BSC	
E	12 BSC	
E1	10 BSC	
e	0.4 BSC	
④ b	0.13	0.23
L	0.45	0.75
L1	1 REF	

NOTES:

1.JEDEC OUTLINE:MS-026 BCE

2.DIMENSIONS D1 AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.25mm PER SIDE. D1 AND E1 ARE MAXIMUM PLASTIC BODY SIZE DIMENSIONS IMCLUDING MOLD MISMATCH.

3.DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION.ALLOWABLE DAMBAR PROTRUSION SHALL NOT CAUSE THE LEAD WIDTH TO EXCEED THE MAXIMUM b DIMENSION BY MORE THAN 0.08mm.