承永資訊科技 CYRUSTEK CO.

ES51920

LCR meter chipset

Features

- 19,999/1,999 counts dual LCD display
- LQFP-48 package for MCU (HT32F65240)
- LQFP-64 package for LCD driver (HT16C23A)
- SSOP-48L package for ES51920
- AutoLCR smart check and measurement
  (Taiwan patent no.: 456205)
- Series/Parallel modes are selectable.
- Ls/Lp/Cs/Cp with D/Q/θ/ESR parameters
- Support DCR mode 200.00Ω~200.0MΩ
- Five different test frequency are available:
  100/120/1k/10k/100k Hz
- Test ac signal level: 0.6mV$_{RMS}$ typ.
- 6 range resistor range used
- Test range: (ex. F=1kHz)
  L: 200.00 μH ~ 2000.0 H
  C: 2000.0 pF ~ 2.000 mF
  R: 20.000 Ω ~ 200.0 MΩ
- Multi-level battery voltage detector
- Support Backlight & Buzzer sound driver
- Source resistance depends on range
  Min: 120Ω typical
  Max:1MΩ typical
- 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

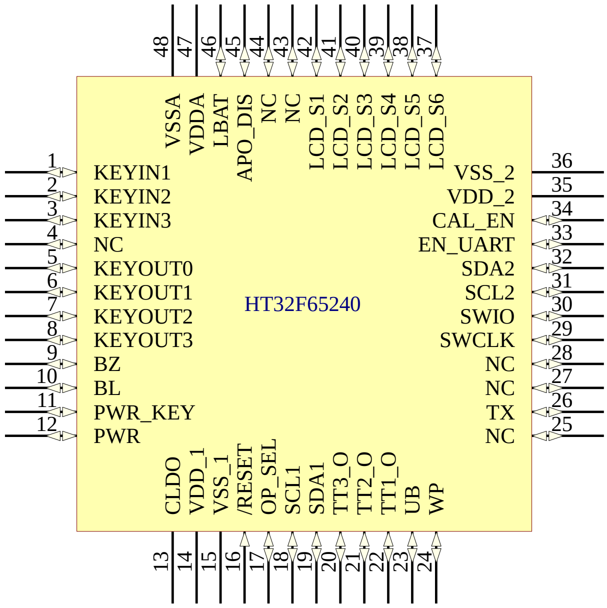
Application

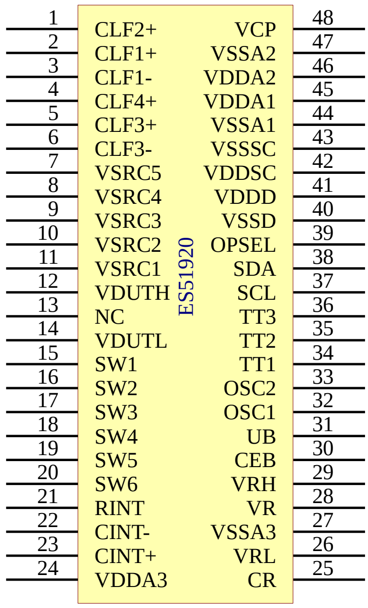
Handheld LCR bridge meter

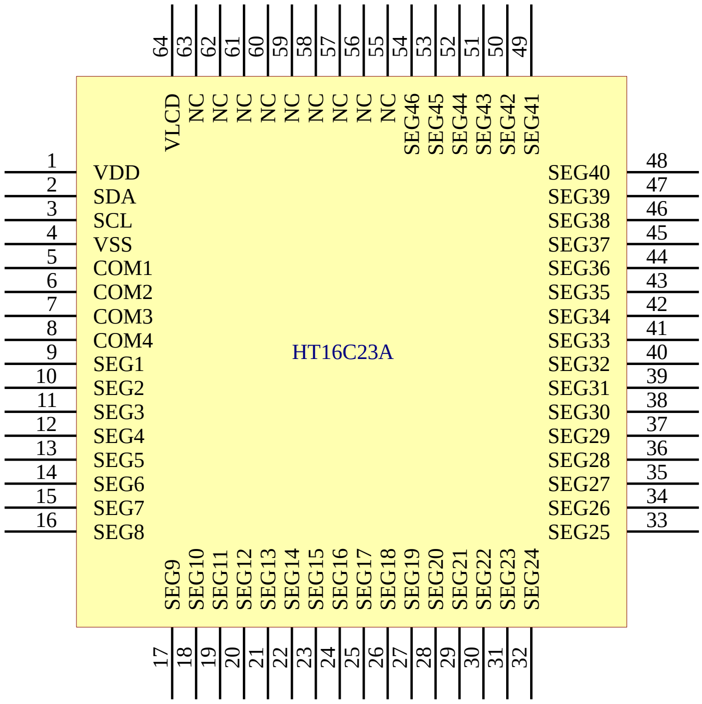
Description

The chipset is suitable for LCR bridge application. By using ES51920 to implement the LCR bridge meter, the complicated PCB design is not necessary. The ES51920 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 MCU is the mix-mode processing chip to handle the calculation of the D/Q/ESR/θ parameter with Ls/Lp/Cs/Cp values. It also provides the user interface and LCD drivers to support dual display operation. Tolerance mode and relative mode 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 4.5digits ADC circuit design is implemented in the chipset. A fully smart measurement for L/C/R is possible. User could measure the DUT impedance simply without change function key at the AUTOLCR smart mode.

Pin Assignment







Pin Description
HT32F65240

Pin No	Symbol	Type	Description
1	KEYIN1	I/O	KEYPAD input 1
2	KEYIN2	I/O	KEYPAD input 2
3	KEYIN3	I/O	KEYPAD input 3
4	NC	-	Not connected
5	KEYOUT0	I/O	KEYPAD output0
6	KEYOUT1	I/O	KEYPAD output1
7	KEYOUT2	I/O	KEYPAD output2
8	KEYOUT3	I/O	KEYPAD output3
9	BZ	O	Buzzer output driver and normal low
10	BL	O	Backlight driver output and normal low
11	PWR_KEY	I	Power keypad sense input
12	PWR	O	Power control output
13	CLDO		External Filter Capacitor Value for Internal Core Power Supply
14	VDD_1	P	Digital power connected to 3.5V
15	VSS_1	G	Digital ground
16	/RESET	I	Power_on_reset
17	OP_SEL	O	High/Low power OPAMP selection
18	SCL1	O	Serial clock for ES51920
19	SDA1	I/O	Serial I/O data for ES51920
20	TT3_O	O	Timing control output3
21	TT2_O	O	Timing control output2
22	TT1_O	O	Timing control output1
23	UB	I	Unbalance detection
24	WP	O	Write protection for 24c02 EEPROM
25	NC	-	Not connected
26	TX	O	UART port output (9600bps)
27	NC	-	Not connected
28	NC	-	Not connected
29	SWDCLK	-	Clock for ISP
30	SWDIO	-	Data for ISP
31	SCL2	O	Serial clock for 24c02 EEPROM and LCD driver
32	SDA2	I/O	Serial I/O data for EEPROM and LCD driver
33	EN_UART	I	Set to VDD to enable the UART port (internal pull-high), set to VS to disable the UART
34	CAL_EN	I	Pull to VDD to make auto calibration procedures available (interna pull-high), set to VSS to disable the UART
35	VDD_2	P	Digital power connected to 3.5V
36	VSS_2	G	Digital ground
37	LCD_S6	I/O	LCD segment_6 defined by user (See SEG39 of LCD table)
38	LCD_S5	I/O	LCD segment_5 defined by user (See SEG39 of LCD table)
39	LCD_S4	I/O	LCD segment_4 defined by user (See SEG39 of LCD table)
40	LCD_S3	I/O	LCD segment_3 defined by user (See SEG41 of LCD table)
41	LCD_S2	I/O	LCD segment_2 defined by user (See SEG41 of LCD table)
42	LCD_S1	I/O	LCD segment_1 defined by user (See SEG41 of LCD table)
43	NC	-	Not connected
44	NC	-	Not connected
45	APO_DIS	I	Set to VDD to disable the auto power off mode
46	LBAT	I	Battery voltage detection input

47	VDDA	I	Reference voltage connected to 3.5V
48	VSSA	G	Analog ground

HT16C23A

1	VDD	P	Digital power connected to 3.5V
2	SDA	I/O	Serial I/O data for EEPROM and LCD driver
3	SCL	O	Serial clock for 24c02 EEPROM and LCD driver
4	VSS	G	Digital ground
5	COM1	O	LCD backplane signal_1
6	COM2	O	LCD backplane signal_1
7	COM3	O	LCD backplane signal_1
8	COM4	O	LCD backplane signal_1
9-54	SEG46-SEG01	O	LCD segment 1-46
55-63	NC	-	Not connected
64	VLCD	P	Power supply for LCD driver (V1 = VLCD See page21)

ES51920

Pin No	Symbol	Type	Description
1	CLF2+	I/O	External capacitor connection for low pass filter
2	CLF1+	I/O	External capacitor connection for low pass filter
3	CLF1-	I/O	External capacitor connection for low pass filter
4	CLF4+	I/O	External capacitor connection for low pass filter
5	CLF3+	I/O	External capacitor connection for low pass filter
6	CLF3-	I/O	External capacitor connection for low pass filter
7	VSRC5	O	Source terminal_5 for DUT
8	VSRC4	O	Source terminal_4 for DUT
9	VSRC3	O	Source terminal_3 for DUT
10	VSRC2	O	Source terminal_2 for DUT
11	VSRC1	O	Source terminal_1 for DUT
12	VDUTH	I	High sensed terminal for DUT
13	NC	-	
14	VDUTL	I	Low sensed terminal for DUT
15	SW1	I	Range ratio resistor1
16	SW2	I	Range ratio resistor2
17	SW3	I	Range ratio resistor3
18	SW4	I	Range ratio resistor4
19	SW5	I	Range ratio resistor5
20	SW6	I	Range ratio resistor6
21	RINT	I/O	Integrator resistor connection
22	CINT-	I/O	Integrator capacitor connection
23	CINT+	I/O	Integrator capacitor connection
24	VDDA3	P	Analog power 3 (3.5V)
25	CR	I	Bias point
26	VRL	O	Common output
27	VSSA3	G	Analog ground 3
28	VR	I	Reference voltage input (V_R-V_{RL} = -500mV typ.)
29	VRH	O	Bandgap voltage output
30	CEB	I	Chip enable input
31	UB	O	Unbalance range output indication
32	OSC1	O	Oscillator output
33	OSC2	I	Oscillator input
34	TT1	I	Timing control input1
35	TT2	I	Timing control input2
36	TT3	I	Timing control input3
37	SCL	I	Serial bus clock
38	SDA	I/O	Serial bus data
39	OPSEL	I	OPAMP power selection
40	VSSD	G	Digital ground
41	VDDD	P	Digital power (3.5V)
42	VDDSC	P	Analog power (3.5V)
43	VSSSC	G	Analog ground
44	VSSA1	G	Analog ground 1
45	VDDA1	P	Analog power 1 (3.5V)
46	VDDA2	P	Analog power 2 (3.5V)

47	VSSA2	G	Analog ground 2
48	VCP	P	OP power (5V)

Absolute Maximum Ratings

Characteristic	Rating
Supply Voltage (VDD to VSS)	7V
Digital Input	VSS -0.6 to VDD +0.6
Power Dissipation. Flat Package	500mW
Operating Temperature	-20℃ to 70℃
Storage Temperature	-50℃ to 125℃

Electrical Characteristics

TA=25℃

Parameter	Symbol	Test Condition	Min.	Typ.	Max	Units
5V Power supply	VCP		—	5.0	—	V
3.5V Power supply	VDDD DVDD VDDA AVDD VDDSC		—	3.5	—	V
5V Supply current	I_{CP}	VCP = 5V	—	1	—	mA
3.5V Supply current DVDD/AVDD =3.5V VDDD/VDDA/VDDSC = 3.5V	I_{DD}	F = 100kHz	—	16.5	18	mA
	I_{DD}	F $\leq$ 10kHz	—	13	15	mA
Test signal amplitude (DC mode)	V_{DUT}	R_{DUT}=10kΩ	—	0.9	—	V
Test signal amplitude (AC mode)	V_{DUT}	R_{DUT}=10kΩ	—	0.63	—	V_{RMS}
Basic accuracy (F $\leq$ 10kHz) See page19 for details	Ae	10-100k Ω range	—	—	±0.2	%F.S[1]
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}	62.5Hz frame rate	—	3.0	—	V
LCD bias voltage configuration			1/4 duty 1/3 bias A-type waveform			
Multi-level low battery detector	Vt1	VREF=3.5V V_{POWER_SENSE}	—	2.801	—	V
	Vt2		—	2.538	—	
	Vt3		—	2.280	—	
	Vt4		—	2.018	—	
Reference voltage input	V_{REF}	VR-VRL	-510	-500	-490	mV

Note:

1. Full Scale : 20000 counts
2. For best integral linearity of ADC, the metalized polypropylene film capacitor for CINT is necessary.
3. It is not recommended to use switching power for power supplying.

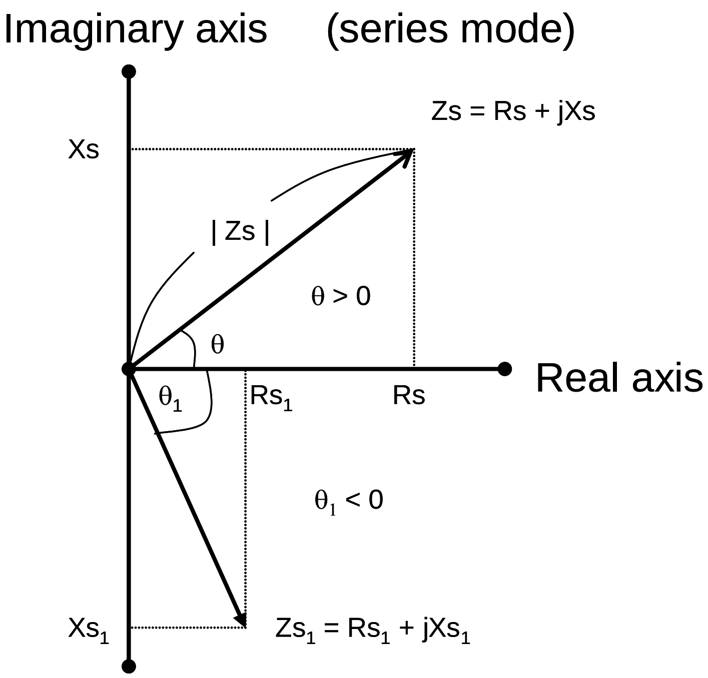
Functional description

Introduction

The 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 (AUTOLCR mode). It means the user could measure the L/C/R components directly at AUTOLCR 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 $|Zs|\angle\theta$

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

Rs = |Zs| cosθ

Xs = |Zs| sinθ

Xs/Rs = tanθ

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

If θ > 0, the reactance is inductive. In other words, if θ < 0, the reactance is capacitive.

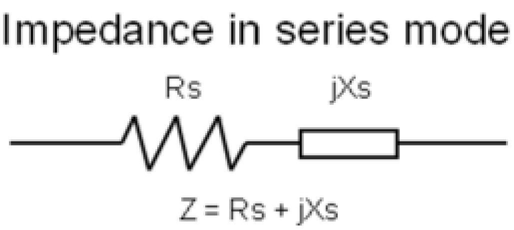
There are two types for reactance. The one is the inductive reactance X_L and the other is the capacitive reactance X_C. They could be defined as: (f = signal frequency)

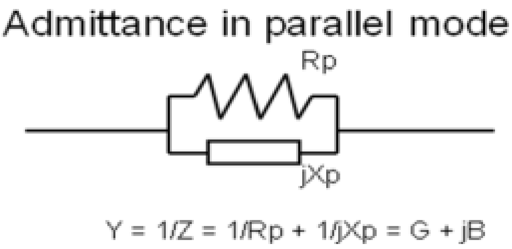
$X_L = 2\pi f L$ (L = Inductance)

$X_C = \dfrac{1}{2\pi f C}$ (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 = tanθ

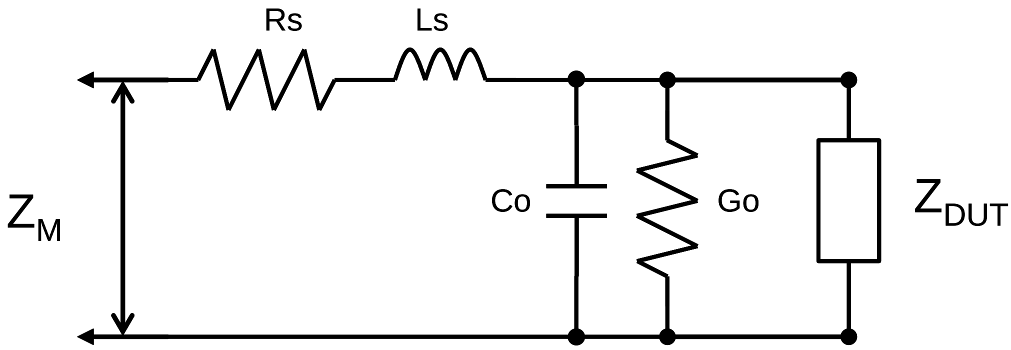
$Q = Xs / Rs = 2\pi f Ls / Rs = 1 / 2\pi f Cs\, Rs$

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

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

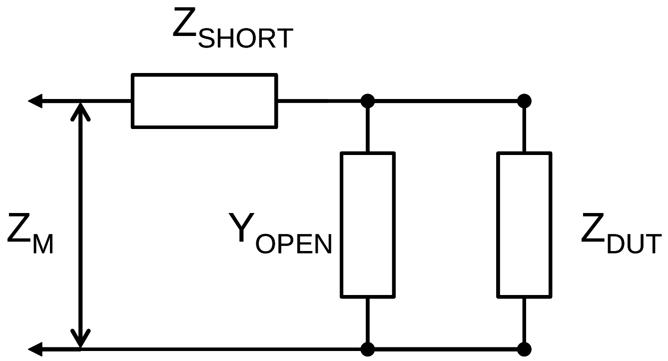
The chipset provides the open/short calibration process to get the better accuracy for high/low impedance measurement. The purpose of open/short calibration is to reduce the parasitic effect of the test fixture.



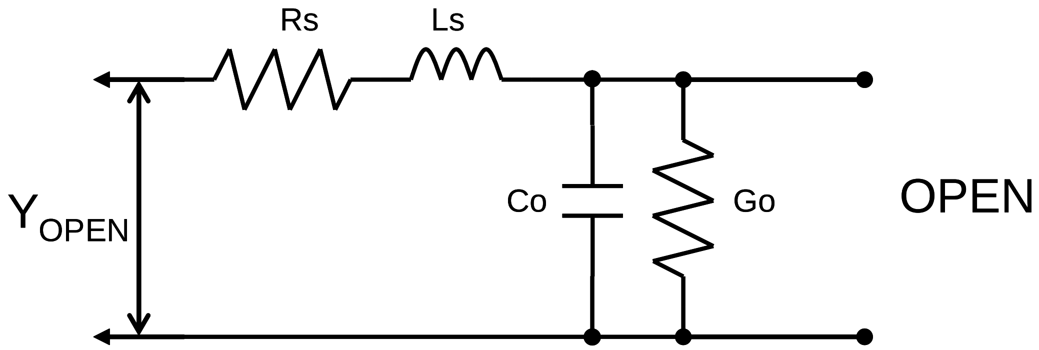
Z_M is defined as total impedance measured to DUT by the special test fixture which has some parasitic impedance. $Z_M = (Rs + j\omega Ls) + (\frac{1}{Go + j\omega Co} \parallel Z_{DUT})$

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 + jωLs and Go+jωCo.

Equivalent circuit

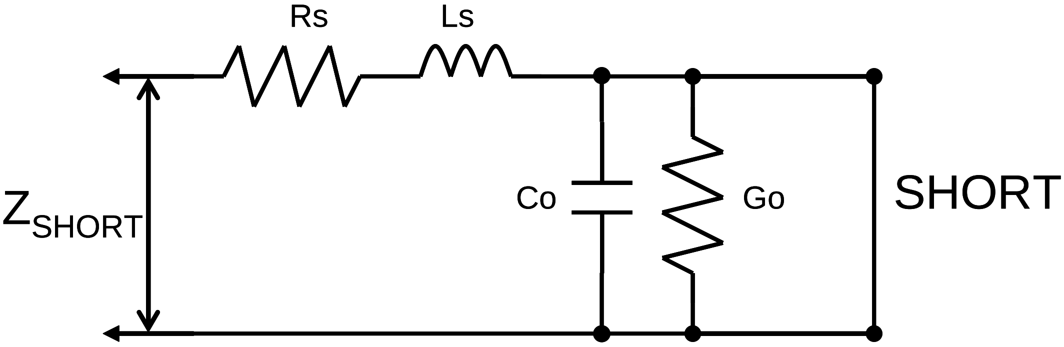


$$Z_{DUT} = \frac{Z_M - Z_{SHORT}}{1-(Z_M-Z_{SHORT})Y_{OPEN}}$$



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

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



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

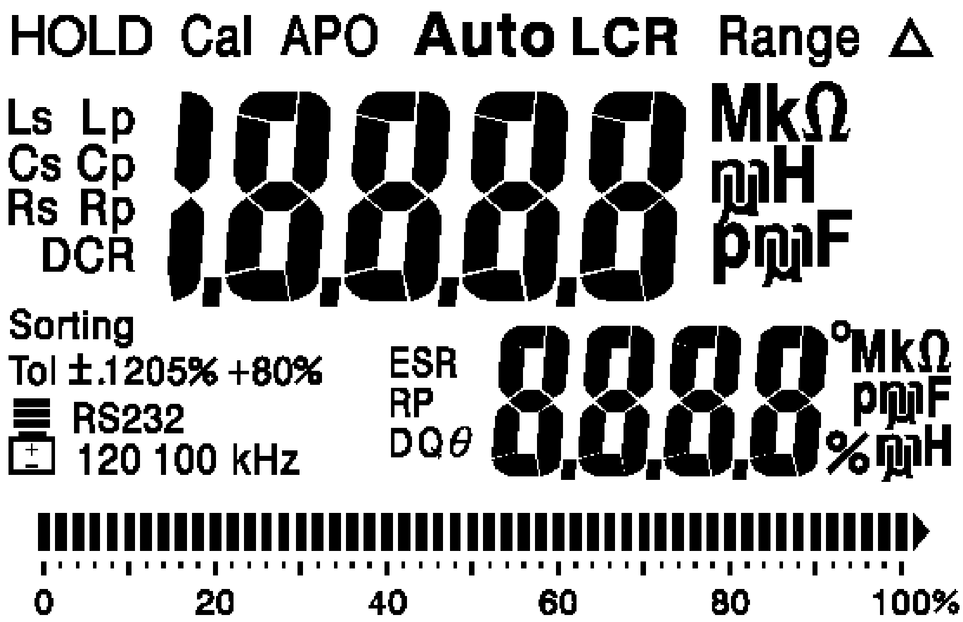
KEYPADS CONFIGURATION

	KEYOUT0	KEYOUT1	KEYOUT2	KEYOUY3
KEYIN1	FUNC	HOLD	SETUP	ENTER
KEYIN2	CAL	SORTING	D/Q/θ ←	SER/PAL →
KEYIN3	BKLIT	FREQ	RS232 ↑	REL% ↓

Push key function allowed to be active will be marked as "◆"

Keypads	FUNC	HOLD	DQθ	S/P	BKLIT	RS232	SORT	REL%	FREQ
AUTOLCR	◆	◆			◆	◆			◆
L	◆	◆	◆	◆	◆	◆	◆	◆	◆
C	◆	◆	◆	◆	◆	◆	◆	◆	◆
ACR	◆	◆		◆	◆	◆	◆	◆	◆
DCR	◆	◆			◆	◆	◆	◆	

OPERATION KEYPAD



1. **Power ON/OFF**
   The PWR_KEY of MCU senses the external push keypad and control the PWR output to enable or disable the whole system power. When power on resets, the all LCD segments will be ON for 2 seconds. Then the default initialization process will be started. The default mode is AUTOLCR smart mode and the default test frequency is 1 kHz. When the PWR_KEY is pushed during power-on mode, the system will enter power-off mode. The LCD will show the “OFF” state before the whole system enters the power off status.

2. **Auto power off**
   In order to extend the battery life, except of using external power supply, APO feature will be helpful. When all function keypads do not be pushed or impedance range switching not detected within 5 minutes, the system will launch the alarm buzzer beep at three times before the auto power-off status. During the period of alarm, the system will be kept in operation by pushing any function key again. If any key is not in operation further, the system power will be off. Set APO_DIS to VDD will turn off the auto power off configuration.

3. **Buzzer driver**

If the function keypad available is pushed, the buzzer output (pin9 of MCU) beeps one 150ms pulse. If the function keypad not available is pushed, the buzzer beeps double 150ms pulses.

4. **Backlight driver**

When user push *BKLIT* keypad, the backlight driver (pin10 of MCU) will be active. Push the BKLIT key again to disable the backlight driver. When all function keypads do not be pushed or impedance range switching not detected within 60 seconds, the backlight driver will be disabled automatically.

5. **Battery detect**

The MCU 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.

6. **Primary impedance with secondary parameter test mode**

When *AUTO/L/C/R* function selection key (FUNC) is pushed, the main test mode could be selected sequentially: Auto-LCR mode → Auto-L mode → Auto-C mode → Auto-R mode → DCR mode → Auto-LCR mode. The default test mode is Auto LCR mode which could check the type of impedance smartly and enter to the L/C/R measurement mode automatically. The secondary parameter will follow the L/C/R measurement. It means that (L + Q), (C + D)[1], (R + θ)[2] are combined in one group respectively. When Auto-L or Auto-C mode is selected, the impedance measurement is auto ranging. The primary LCD display will show the inductance or capacitance of DUT. The secondary LCD display will show the quality or dissipation factor. The phase angle or equivalent resistance can also be shown by pushing the PARAMETER (D/Q/θ) keypad to choose D/Q/θ/ESR. When Auto-R (ACR mode) or DCR mode is selected, the secondary parameter is omitted.

[1]Note: When Auto-LCR mode is active, the secondary parameter will show the equivalent resistance in parallel mode (Rp) to replace the D factor if the C measured value of DUT is less than 5pF.

[2]Note: Auto-LCR mode only. During Auto-R mode or DCR mode, the secondary parameter is not available.

7. Auto LCR smart mode

Due to high performance circuit design, the system decide which device measurement (L or C or R) is the best representation of DUT.

If $|\theta| < 11^o$, the Auto-R mode is selected. The parameter on sub-display is θ.

If $\theta > 11^o$, the Auto-L mode is selected. The parameter on sub-display is Q.

If $\theta < -11^o$, the Auto-C mode is selected. The parameter on sub-display is D. If the C < 5pF, the parameter on sub-display is parallel resistance Rp.

8. Series/Parallel mode select

When any L/C/R functional mode is selected, the default measurement in series or parallel mode is auto selected and the AUTO segment will be shown on LCD display. It depends on the total equivalent impedance measured. If the impedance is larger than 10kΩ, parallel mode is set and Lp/Cp/Rp is shown on the display. If it is less than 10kΩ, series mode is set and Ls/Cs/Rs is shown on the display. When *SEL/PAL* key is pushed, the impedance measurement will be set in series mode or in parallel mode sequentially. The LCD annunciators for $L_S/L_P/C_S/C_P/R_S/R_P$ symbols will be indicated by related LCR measurement mode setting.

9. Hold mode

Push the *HOLD* key to stop the reading of DUT on primary display. The current value of DUT will be updated continuously on the secondary LCD display. Push the *HOLD* key again to cancel the hold mode and return to the original measurement mode.

10. RS232 mode

Set EN_UART (pin33 of MCU) to VDD to enable the UART port available. Push the *RS232* key to start a 9600bps RS232 transmission active. Push the *RS232* key again to cancel the transmission. When RS232 output port is transmitting, a RS232 indication of LCD segment will be active.

11. Relative mode

Push the *Relative* key to reserve the current DUT readings (D_{CUR}) on primary display as a reference value (D_{REF}) and the "Δ" annunciator will be active. The secondary display will show the percentage of relative value REL%. The REL% = (D_{CUR} – D_{REF}) / D_{REF} * 100%. Push the *Relative* key again to show the reference value D_{REF} on primary display and the "Δ" segment will be blinking. The percentage range is from -99.9%~99.9%. When the relative value is larger than double of reference value (D_{REF}), the "OL%" indication will be shown on the secondary display.

12. Calibration mode

In order to improve the accuracy of high/low impedance, it is recommended to do OPEN/SHORT calibration mode before measurement. Push *CAL* keypad larger than 2 seconds to start the open/short calibration procedure: OPEN ready → OPEN calibration → SHORT ready → SHORT calibration. During open or short calibration processing, the 30-second countdown will be shown on LCD panels. If the calibration procedure is finished, the PASS or FAIL symbol will shown on the primary display. If PASS symbol for both OPEN and SHORT modes, the calibration data will be saved to external EEPROM after push CAL key again.

13. Sorting mode

The sorting mode could help the user to make a quick sort for a bunch of components. Push *SORT* key to enter to the sorting mode which will be set to 2000 digits display automatically. If the LCD reading is OL or less than 200 counts, the *SORT* key is not available. The primary display to show PASS or FAIL status depends on whether the impedance measured exceeds tolerance range. The current measurement result will be shown on the secondary display. When sorting mode is active, push *SETUP* keypad to modify the reference value, range and the tolerance settings sequentially. If the target is reached, push *ENTER* keypad to confirm it. Use the 4 direction keypads (↑ / ↓ /←/→) to change the target data easily. The reference value setting is available from 20 to 1999 counts. The tolerance range setting selection: ±0.25% → ±0.5% → ±1% → ±2% → ±5% → ±10% → ±20% → +80%-20%. The default tolerance is ±1%.

14. Test frequency select

When *FREQ* key is pushed, the test frequency will be changed sequentially. There are five different test frequencies (100Hz/120Hz/1kHz/10kHz/100kHz) can be selected. The LCR impedance scale ranges are depended on the test frequency. See next table of scale range description.

Resistance display range

Function	Frequency	Scale Range	Resolution
R_S/R_P	100Hz/120Hz	200.00Ω	0.01Ω
	100Hz/120Hz	2.0000kΩ	0.1Ω
	100Hz/120Hz	20.000kΩ	1Ω
	100Hz/120Hz	200.00kΩ	0.01kΩ
	100Hz/120Hz	2.0000MΩ	0.1kΩ
	100Hz/120Hz	20.000MΩ	1kΩ
	100Hz/120Hz	200.0MΩ	0.1MΩ
	1kHz	20.000Ω	1mΩ
	1kHz	200.00Ω	0.01Ω
	1kHz	2.0000kΩ	0.1Ω
	1kHz	20.000kΩ	1Ω
	1kHz	200.00kΩ	0.01kΩ
	1kHz	2.0000MΩ	0.1kΩ
	1kHz	20.000MΩ	1kΩ
	1kHz	200.0MΩ	0.1MΩ
	10kHz	20.000Ω	1mΩ
	10kHz	200.00Ω	0.01Ω
	10kHz	2.0000kΩ	0.1Ω
	10kHz	20.000kΩ	1Ω
	10kHz	200.00kΩ	0.01kΩ
	10kHz	2.0000MΩ	0.1kΩ
	10kHz	20.00MΩ	0.01MΩ
	100kHz	20.000Ω	1mΩ
	100kHz	200.00Ω	0.01Ω
	100kHz	2.0000kΩ	0.1Ω
	100kHz	20.000kΩ	1Ω
	100kHz	200.00kΩ	0.01kΩ
	100kHz	2.000MΩ	1kΩ

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
	20.000MΩ	1kΩ
	200.0MΩ	0.1MΩ

Capacitance display range

Function	Frequency	Scale Range	Resolution
C_S/C_P	100Hz/120Hz	20.000nF[1]	1pF
	100Hz/120Hz	200.00nF	0.01nF
	100Hz/120Hz	2000.0nF	0.1nF
	100Hz/120Hz	20.000uF	1nF
	100Hz/120Hz	200.00uF	0.01uF
	100Hz/120Hz	2000.0uF	0.1uF
	100Hz/120Hz	20.00mF	0.01mF
	1kHz	2000.0pF	0.1pF
	1kHz	20.000nF	1pF
	1kHz	200.00nF	0.01nF
	1kHz	2000.0nF	0.1nF
	1kHz	20.000uF	1nF
	1kHz	200.00uF	0.01uF
	1kHz	2000uF	1uF
	10kHz	200.00pF	0.01pF
	10kHz	2000.0pF	0.1pF
	10kHz	20.000nF	1pF
	10kHz	200.00nF	0.01nF
	10kHz	2000.0nF	0.1nF
	10kHz	20.000uF	1nF
	10kHz	200.0uF	0.1uF
	100kHz	200.00pF	0.01pF
	100kHz	2000.0pF	0.1pF
	100kHz	20.000nF	1pF
	100kHz	200.00nF	0.01nF
	100kHz	2000.0nF	0.1nF
	100kHz	20.00uF	0.01uF

[1]If the counts of LCD display are less than 2000, the unit will be “pF”.

Inductance display range

Function	Frequency	Scale Range	Resolution
L_S/L_P	100Hz/120Hz	20.000mH[2]	1uH
	100Hz/120Hz	200.00mH	0.01mH
	100Hz/120Hz	2000.0mH	0.1mH
	100Hz/120Hz	20.000H	1mH
	100Hz/120Hz	200.00H	0.01H
	100Hz/120Hz	2000.0H	0.1H
	100Hz/120Hz	20.000kH	0.001kH
	1kHz	2000.0uH	0.1uH
	1kHz	20.000mH	1uH
	1kHz	200.00mH	0.01mH
	1kHz	2000.0mH	0.1mH
	1kHz	20.000H	1mH
	1kHz	200.00H	0.01H
	1kHz	2000.0H	0.1H
	10kHz	200.00uH	0.01uH
	10kHz	2000.0uH	0.1uH
	10kHz	20.000mH	1uH
	10kHz	200.00mH	0.01mH
	10kHz	2000.0mH	0.1mH
	10kHz	20.000H	1mH
	100kHz	20.000uH	0.001uH
	100kHz	200.00uH	0.01uH
	100kHz	2000.0uH	0.1uH
	100kHz	20.000mH	1uH
	100kHz	200.00mH	0.01mH

[2]If the counts of LCD display are less than 2000, the unit will be “uH”.

Accuracy (Ae) vs. Impedance (Z_{DUT}) @ Ta =18 ~ 28 ℃

Freq. / Z	0.1- 1Ω	1 – 10Ω	10 – 100kΩ	100k – 1MΩ	1M – 20MΩ	20M– 200MΩ	Remark
DCR	1.0%+5d	0.5%+3d	0.3%+2d	0.5%+3d	1.0%+5d	2.0%+5d	
100/120Hz	1.0%+5d	0.5%+3d	0.3%+2d	0.5%+3d	1.0%+5d	2.0%+5d	
1kHz	1.0%+5d	0.5%+3d	0.3%+2d	0.5%+3d	1.0%+5d	5.0%+5d	D < 0.1
10kHz	1.0%+5d	0.5%+3d	0.3%+2d	0.5%+3d	2.0%+5d	N/A	
100kHz	2.0%+5d	1.0%+5d	0.5%+3d	1.0%+5d	2.0%+5d (1M – 2MΩ)		

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 ES51920.

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)

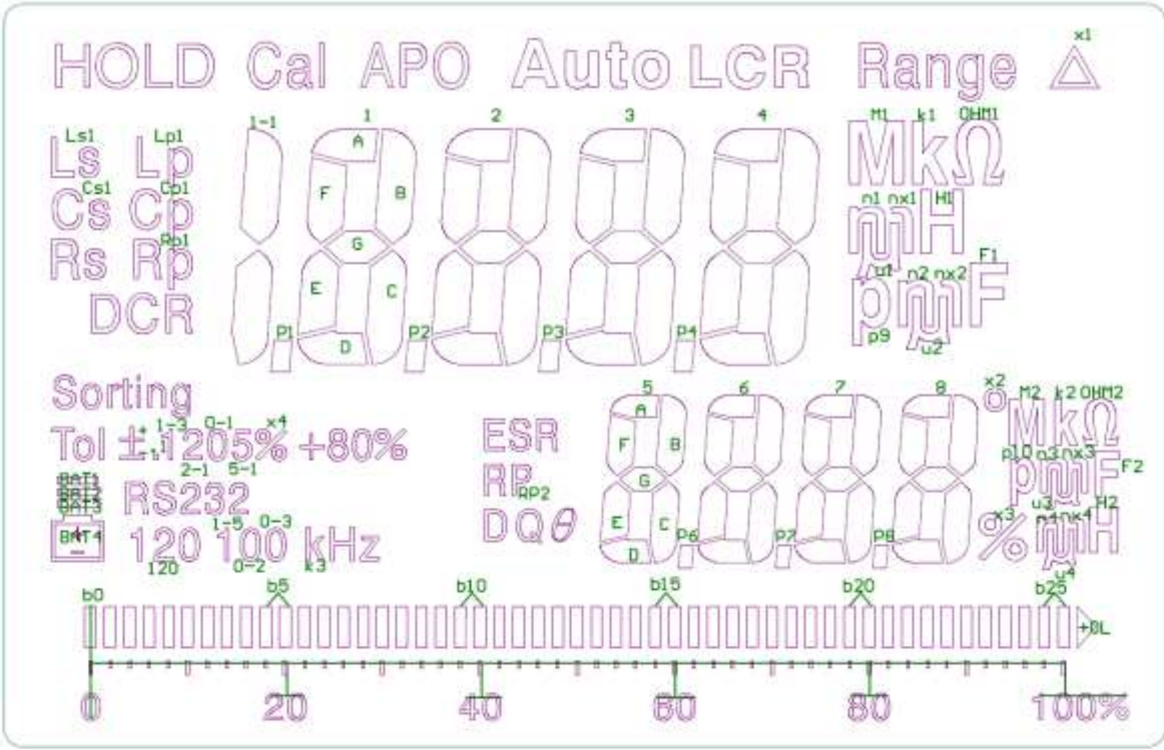
4-terminals measurement with guard shielding

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

LCD Segment	COM1	COM2	COM3	COM4
SEG01	Ls1	Cs1	Rs	
SEG02	Lp1	Cp1	Rp1	DCR
SEG03		1-1		
SEG04	1A	1F	1E	P1
SEG05	1B	1G	1C	1D
SEG06	2A	2F	2E	P2
SEG07	2B	2G	2C	2D
SEG08	3A	3F	3E	P3
SEG09	3B	3G	3C	3D
SEG10	4A	4F	4E	P4
SEG11	4B	4G	4C	4D
SEG12	HOLD	CAL	APO	
SEG13	Auto	LCR	Range	x1
SEG14	p9	M1	k1	Ω1
SEG15	n1	u1	nx1	H1
SEG16	n2	u2	nx2	F1
SEG17	ESR	D		
SEG18	RP2	Q	θ	
SEG19			F2	H2
SEG20	5A	5F	5E	
SEG21	5B	5G	5C	5D
SEG22	6A	6F	6E	P6
SEG23	6B	6G	6C	6D
SEG24	7A	7F	7E	P7
SEG25	7B	7G	7C	7D
SEG26	8A	8F	8E	P8
SEG27	8B	8G	8C	8D
SEG28		x2	p10	x3
SEG29		M2	n3	n4
SEG30		k2	u3	u4
SEG31		Ω2	nx3	nx4
SEG32	b0	b1	b2	b3
SEG33	b7	b6	b5	b4
SEG34	b8	b9	b10	b11
SEG35	b15	b14	b13	b12
SEG36	b16	b17	b18	b19
SEG37	b23	b22	b21	b20
SEG38		b24	b25	+OL
SEG39		LCD_S4	LCD_S5	LCD_S6
SEG40	0-2	0-3	k3	Hz
SEG41		LCD_S1	LCD_S2	LCD_S3
SEG42	BAT4	BAT3	120	1-5
SEG43	BAT1	BAT2	RS232	
SEG44	TOL	-	2-1	0-1
SEG45	+	o1	1-3	
SEG46	Sorting	5-1	x4	+80%

LCD configuration

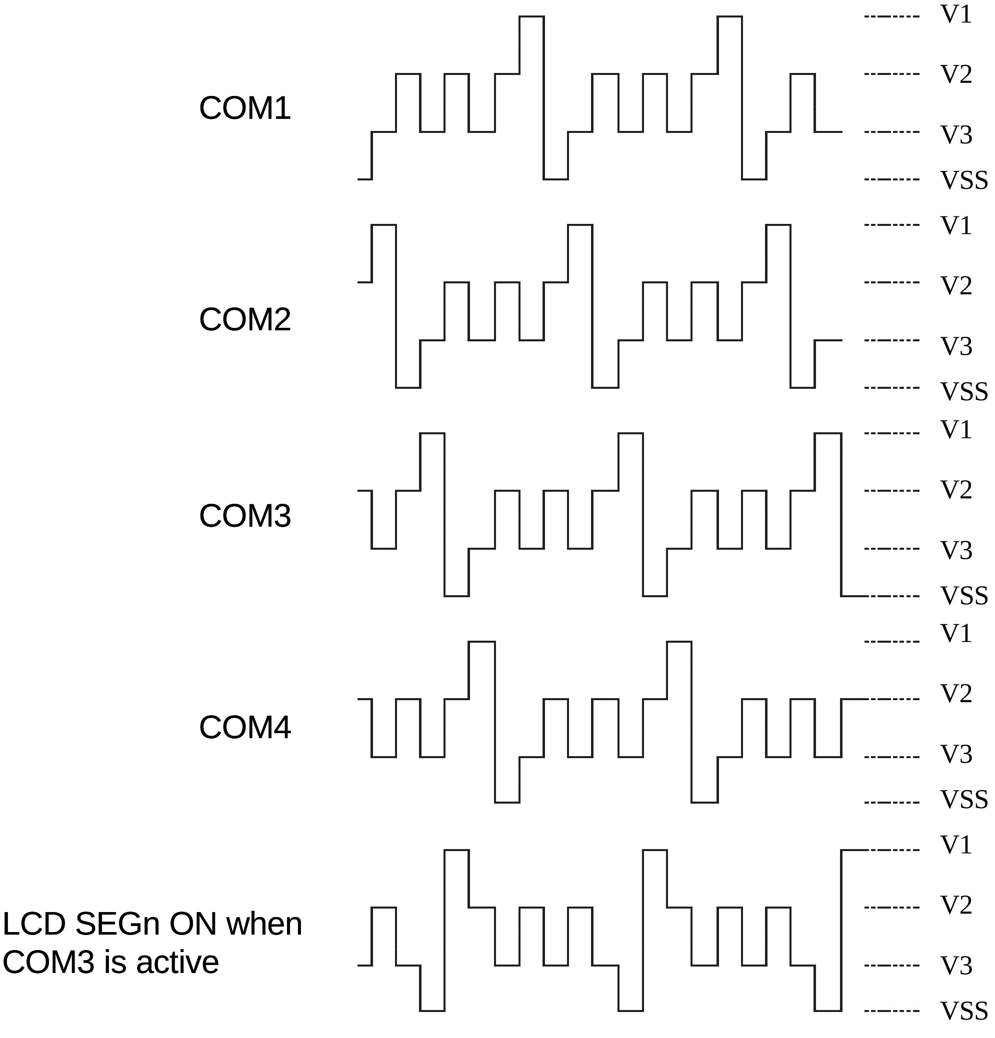


LCD display active condition

LCD annunciates	Condition
Ls1/Cs1	Inductance or Capacitance in series mode is active.
Lp1/Cp1	Inductance or Capacitance in parallel mode is active.
Rs/ESR	AC Resistance in series mode/Equivalence series resistance is active.
Rp1/Rp2	AC Resistance in parallel mode is active.
DCR	DC resistance mode is selected
HOLD	HOLD function is enabled.
CAL	Open/Short calibration process is enabled
APO	Auto power off function is available.
Auto	Impedance measured in series or in parallel automatically
LCR	Checking for L/C/R mode automatically
Range	Range selection is enabled on setup menu of sorting mode.
X1(Δ)	Relative percentage function is enabled.
θ/x2	Phase angle for impedance measurement
x3	The percentage display in relative mode
p9/p10	In capacitance mode and the range displayed is in the order of pF
M1/M2	In resistance mode and the range displayed is in the order of MΩ
k1/k2	In resistance mode and the range displayed is in the order of kΩ In inductance mode and the range displayed is in the order of kH
n1/nx1/n4/nx4	In inductance mode and the range displayed is in the order of mH
u1/u4	In inductance mode and the range displayed is in the order of uH
n2/nx2/n3/nx3	In capacitance mode and the range displayed is in the order of mF
u2/u3	In capacitance mode and the range displayed is in the order of uF
D/Q	Dissipation or Quality factor is active for L/C measurement mode
b0-b25	Bar-graph display
Sorting	Sorting function is enabled

Tol ±.1205%+80%	Tolerance indication in sorting mode
RS232	UART transmission is active
k3/Hz	Test frequency indication
BAT1-BAT4	Battery voltage indication
p1-p8	Decimal points on primary and secondary display
nA-nG	Seven-segment display of n[th] digit
LCD_Sn	LCD segment hardware defined by user (MCU pin37-42)

LCD COM/SEG driver output



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

RS232 transmission format

When *EN_UART* pin (pin33 of MCU) is pulled to VDD, it means the UART port is available. Push RS232 function key to enable the RS232 transmission. The packet rate is two times per second. Each transmission includes 17 bytes totally.

Baud rate	9600 bps
Start bit	1 bit
Data bits	8 bits
Stop bit	1 bit
Parity	No Parity

Data transmission configuration

Byte 0	Byte 1	Byte 2 - 14	Byte 15	Byte 16
00H	0DH	Data	0DH	0AH

Data format description

Byte No.	Data byte	Function
0	START	The content of start byte is 00h
1	LENGTH	The data length of transmission is 13 bytes (ODh)
2	STATUS0	Status0 indication
3	STATUS1	Status1 indication
4	STATUS2	Status2 indication
5	MMOD	Operation mode of primary display
6	MREADH	High byte of primary display data
7	MREADL	Low byte of primary display data
8	MSCOPE	Ranging information of primary display data
9	MSTATUS	Status byte of primary display data
10	SMOD	Operation mode of secondary display
11	SREADH	High byte of secondary display data
12	SREADL	Low byte of secondary display data
13	SSCOPE	Ranging information of secondary display data
14	SSTATUS	Status byte of secondary display data
15	END0	The content of end0 byte is 0Dh
16	END1	The content of end1 byte is 0Ah

STATUS0 (Byte 2)

Bit No.	Data bit	Function
0	HOLD	Set to 1 when data hold is active
1	RELRF	Set to 1 when relative reference mode is active
2	REL	Set to 1 when relative % mode is active
3	CAL	Set to 1 when open/short calibration mode is active
4	SORT	Set to 1 when sorting mode is active
5	AUTOLCR	Set to 1 when auto LCR smart mode is active
6	AMOD	Set to 1 when auto series/parallel mode is active
7	MOD	LCR test mode: 0: in series 1: in parallel

STATUS1 (Byte 3)

Bit No.	Data bit	Function
0	Extra4	User define LCD segment
1	Extra5	User define LCD segment
2	Extra6	User define LCD segment
3 4	BAT0 BAT1	Battery life indication: 00: Lower than 5% 01: Lower than 30% 10: Lower than 60% 11: Higher than 60%
5 6 7	FREQ0 FREQ1 FREQ2	Test frequency ranges: 000: 100Hz 001: 120Hz 010: 1kHz 011: 10kHz 100: 100kHz

STATUS2 (Byte 4)

Bit No.	Data bit	Function
0 1 2 3	SORTP0 SORTP1 SORTP2 SORTP3	Tolerance range at sorting mode: 0011: ± 0.25% 0100: ± 0.5% 0101: ± 1.0% 0110: ± 2.0% 0111: ± 5.0% 1000: ± 10.0% 1001: ± 20.0% 1010: +80%/-20%
4	Extra1	User define LCD segment
5	Extra2	User define LCD segment
6	Extra3	User define LCD segment
7	X	Not available

MMOD (Byte 5)

Bit No.	Data bit	Function
0 1 2	MMOD0 MMOD1 MMOD2	Primary display mode: 000: None 001: L (Inductance) mode 010: C (Capacitance) mode 101: R (Resistance) mode 100: DCR mode
3	X	Not available
4	X	Not available
5	X	Not available
6	X	Not available
7	X	Not available

MREADH (Byte 6) / MREADL (Byte 7)

Bit No.	Data bit	Function
0 1 2 3 4 5 6 7	MRL0 | MRL7	Primary data readings: 16-bit binary code
0 1 2 3 4 5 6 7	MRH0 | MRH7	

MSCOPE (Byte 8)

Bit No.	Data bit	Function
0 1 2	MDOT0 MDOT1 MDOT2	Decimal point location on primary display : 000: 19999 001: 1999.9 010: 199.99 011: 19.999 100: 1.9999
3 4 5 6 7	MUNIT0 MUNIT1 MUNIT2 MUNIT3 MUNIT4	Unit of ranging on primary display: 00000: None 00001: Ω 00010: kΩ 00011: MΩ 00100: None 00101: uH 00110: mH 00111: H 01000: kH 01001: pF 01010: nF 01011: uF 01100: mF

MSTATUS (Byte 9)

Bit No.	Data bit	Function
0 1 2 3 4	MDIS0 MDIS1 MDIS2 MDIS3 MDIS4	The contents on primary display: 00000: Number 00001: Space 00010: Dash 00011: OL 00100: OFF 00101: None 00110: Err 00111: Pass 01000: Fail 01001: Open 01010: Short (Srt)
5	MDASH	Set to 1 if dash"----" shown on display
6	MOL	Set to 1 if OL shown on display
7	MCNT	Primary display count: 0: 20000 counts 1: 2000 counts

SMOD (Byte 10)

Bit No.	Data bit	Function
0 1 2	SMOD0 SMOD1 SMOD2	Secondary display mode: 000: None 001: D (Dissipation factor) 010: Q (Quality factor) 101: ESR or Rp (Equivalent resistance) 100: θ (Phase angle)
3	X	Not available
4	X	Not available
5	X	Not available
6	X	Not available
7	X	Not available

SREADH (Byte 11) / SREADL (Byte 12)

Bit No.	Data bit	Function
0 1 2 3 4 5 6 7	SRL0 | SRL7	Secondary data readings: 16-bit binary signed code
0 1 2 3 4 5 6 7	SRH0 | SRH7	

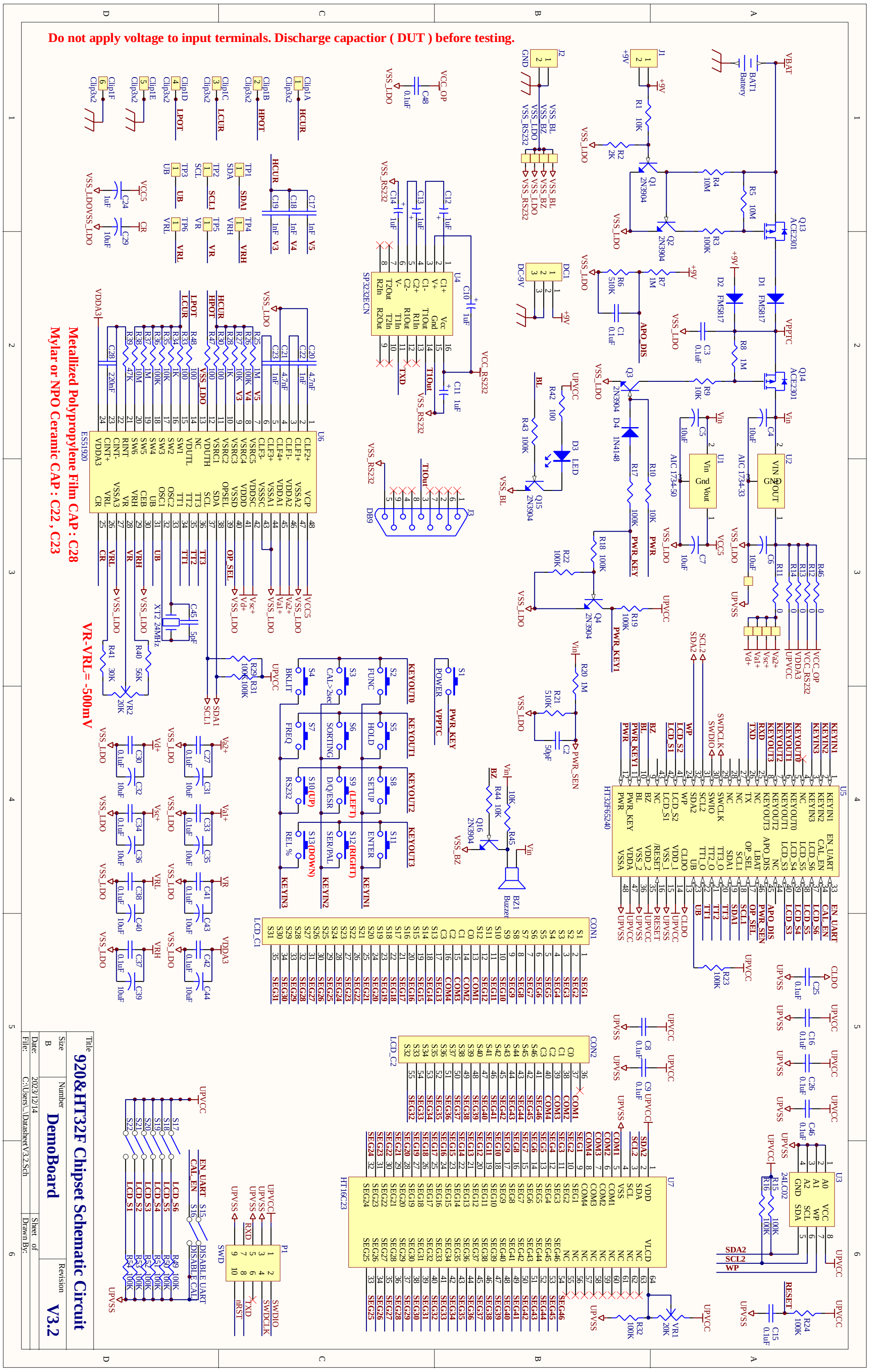
SSCOPE (Byte 13)

Bit No.	Data bit	Function
0 1 2	SDOT0 SDOT1 SDOT2	Decimal point location on secondary display : 000: 19999 001: 1999.9 010: 199.99 011: 19.999 100: 1.9999
3 4 5 6 7	SUNIT0 SUNIT1 SUNIT2 SUNIT3 SUNIT4	Unit of ranging on secondary display: 00000: None 00001: Ω 00010: kΩ 00011: MΩ 00100: None 00101: uH 00110: mH 00111: H 01000: kH 01001: pF 01010: nF 01011: uF 01100: mF 01101: % 01110: deg

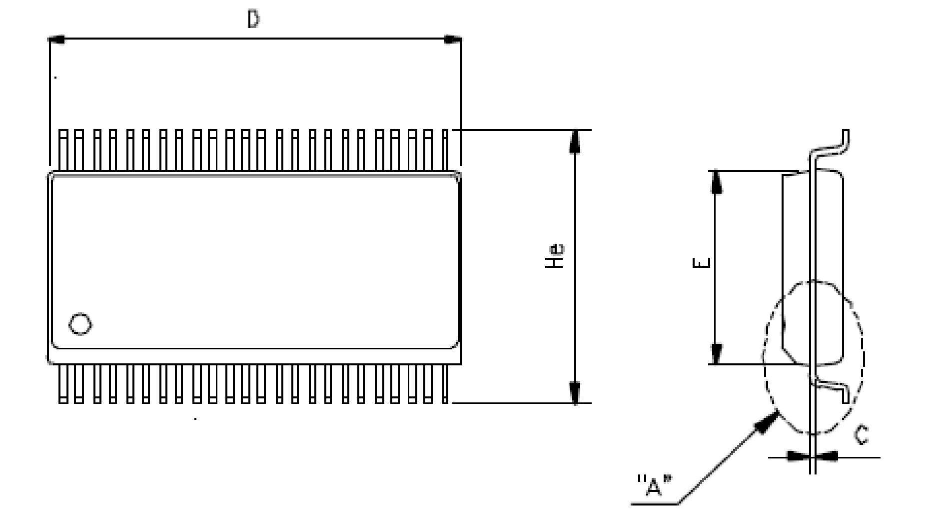
SSTATUS (Byte 14)

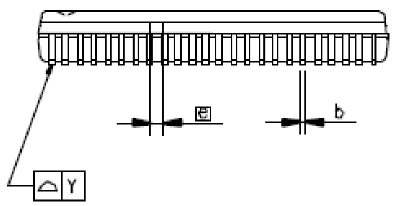
Bit No.	Data bit	Function
0 1 2 3 4	MDIS0 MDIS1 MDIS2 MDIS3 MDIS4	The contents on secondary display: 00000: Number 00001: Space 00010: Dash 00011: OL 00100: OFF 00101: None 00110: Err 00111: Pass 01000: Fail 01001: Open 01010: Short (Srt)
5	MDASH	Set to 1 if dash(“----“) shown on display
6	MOL	Set to 1 if OL shown on display
7	MCNT	Primary display count: 0: 20000 counts 1: 2000 counts

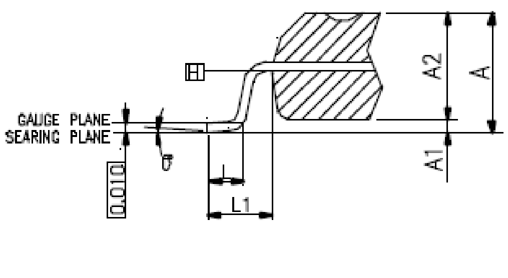
Application circuit



Package information (SSOP-48L)







DETAIL : A

SYMBOLS	MIN.	NOM.	MAX.
A	0.095	0.102	0.110
A1	0.008	0.012	0.016
A2	0.089	0.094	0.099
b	0.008	0.010	0.013
c	–	0.008	–
D	0.620	0.625	0.630
E	0.291	0.295	0.299
e	–	0.025	–
He	0.396	0.406	0.416
L	0.020	0.030	0.040
L1	–	0.056	–
Y	–	–	0.003
θ°	0°	–	8°

UNIT : INCH

NOTES:

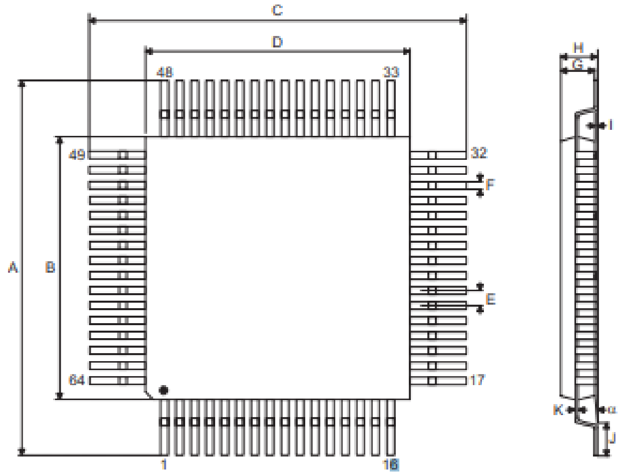
1.DATUM PLANE H IS LOCATED AT THE BOTTOM OF THE MOLD PARTING LINE COINCIDENT WITH WHERE THE LEAD EXITS THE BODY.

2.DIMENSIONS E AND D DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 6 MIL PER SIDE. DIMENSIONS E AND D DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H

3.DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION.

Package information (LQFP-64)

64-pin LQFP (7mm×7mm) Outline Dimensions

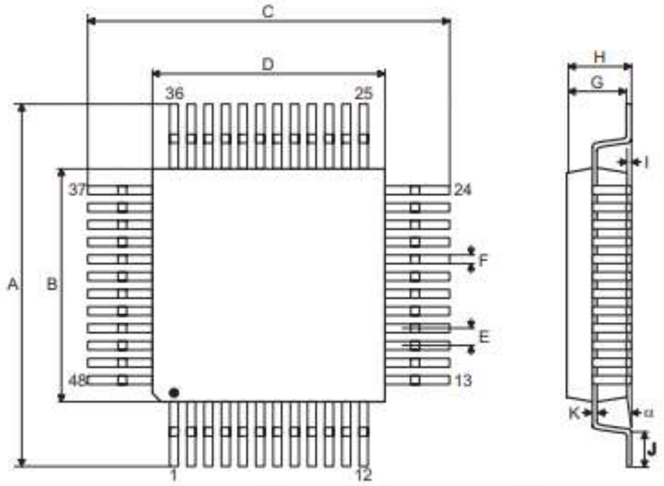


Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	—	0.354 BSC	—
B	—	0.276 BSC	—
C	—	0.354 BSC	—
D	—	0.276 BSC	—
E	—	0.016 BSC	—
F	0.005	0.007	0.009
G	0.053	0.055	0.057
H	—	—	0.063
I	0.002	—	0.006
J	0.018	0.024	0.030
K	0.004	—	0.008
α	0°	—	7°

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	—	9.00 BSC	—
B	—	7.00 BSC	—
C	—	9.00 BSC	—
D	—	7.00 BSC	—
E	—	0.40 BSC	—
F	0.13	0.18	0.23
G	1.35	1.40	1.45
H	—	—	1.60
I	0.05	—	0.15
J	0.45	0.60	0.75
K	0.09	—	0.20
α	0°	—	7°

Package information (LQFP-48)

48-pin LQFP (7mm×7mm) Outline Dimensions



Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	—	0.354 BSC	—
B	—	0.276 BSC	—
C	—	0.354 BSC	—
D	—	0.276 BSC	—
E	—	0.020 BSC	—
F	0.007	0.009	0.011
G	0.053	0.055	0.057
H	—	—	0.063
I	0.002	—	0.006
J	0.018	0.024	0.030
K	0.004	—	0.008
α	0°	—	7°

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	—	9.0 BSC	—
B	—	7.0 BSC	—
C	—	9.0 BSC	—
D	—	7.0 BSC	—
E	—	0.5 BSC	—
F	0.17	0.22	0.27
G	1.35	1.4	1.45
H	—	—	1.60
I	0.05	—	0.15
J	0.45	0.60	0.75
K	0.09	—	0.20
α	0°	—	7°