承永資訊科技 CYRUSTEK CO.

ES51930

10kHz LCR analog front

Features

- 6000 counts ADC resolution
- LQFP-80L package
- Dual power supply needed
- High performance analog front end for impedance (Z) measurement
  (Taiwan patent no.: 456205)
- Support Z/DCR measurement for LCR mode
- Built-in simple DMM front end circuit to support DCV/Freq./Diode/NCV mode
- Four different test frequency are available: 100/120/1k/10k Hz for Z measurement
- Test signal level: 0.5V_{RMS} / 0.1V_{RMS} typ.
- 6 ratio resistor range used for LCR mode
- Test range:
  L: 600.0 μH ~ 200.0 H
  C: 600.0 pF ~ 10.00 mF
  R: 60.00 Ω ~ 20.00 MΩ
- Low battery voltage detector
- Support buzzer sound driver with driving pattern & frequency selectable
- Min. source resistance: 120Ω typical

Description

The ES51930 is the analog frond end chip suitable for LCR bridge meter with simple DMM function. By using ES51930 to implement the LCR bridge meter, the complicated PCB design is not necessary. The ES51930 is built-in resistor switches network to provide different ranges control. It also provides a high performance integrated circuit by the test signal with different frequency to measure the complex impedance of the device. The ES51930 includes a flexible serial interface to external MCU. The MCU could get the real part and imaginary part of complex impedance from ES51930 directly and calculate the D/Q/R/θ parameter with L or C values easily. The ES51930 also supports simple DMM function includes DC voltage, frequency counter, diode forward voltage and not-contact electric field measurement.

Application

Handheld LCR / DMM meter

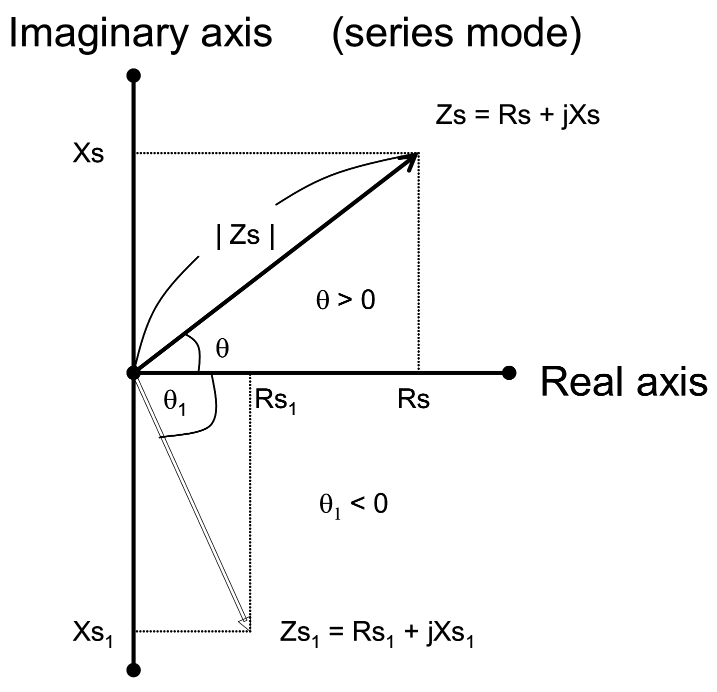
1. Functional description

1.1 Overview

The ES51930 is an analog front end IC built-in multiple measurement modes for LCR/DMM application. The LCR mode could measure complex impedance (Inductance/Capacitance/Resistance) with secondary parameters including dissipation factor (D), quality factor (Q), phase angle (θ), equivalent series or parallel resistance (ESR or Rp). The DMM mode could measure DC voltage, frequency counter, diode forward voltage and non-contact ac electric filed (NCV). The ES51930 also provides a flexible serial interface for external microprocessor operation. The external microprocessor could implement a fully auto range LCR/DMM product by proper firmware design with ES51930.

1.2 Basic impedance theory

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 $|Zs|\angle\theta$

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

$Rs = |Zs| \cos\theta$

$Xs = |Zs| \sin\theta$

$Xs/Rs = \tan\theta$

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

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

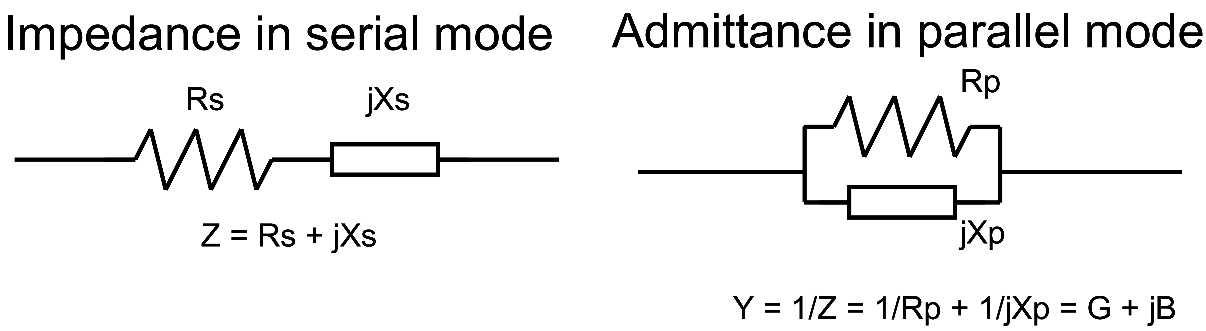
There are two types for reactance. The one is the inductive reactance X_L and the other is the capacitive reactance X_C. They could be defined as: (f = test signal frequency)

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

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

1.5 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 also more important. 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 also no effect. Therefore, use series mode to measure lower value inductor and use parallel mode to measure higher value inductor.

1.3 Scale range configuration

LCR mode			
Function mode	Frequency	Meas. Range	Min. resolution
Inductance Ls/Lp	100/120Hz	60.00mH~200.0H	0.01mH
	1kHz	6000uH~60.00H	1uH
	10kHz	600.0uH~6.000H	0.1uH
Capacitance Cs/Cp	100/120Hz	60.00nF~10.00mF	0.01nF
	1kHz	6.000nF~600.0uF	1pF
	10kHz	600.0pF~60.00uF	0.1pF
Resistance Rs/Rp	100/120Hz	60.00Ω~20.00MΩ	0.01Ω
	1kHz	60.00Ω~20.00MΩ	0.01Ω
	10kHz	60.00Ω~20.00MΩ	0.01Ω
DC resistance	N/A	600.0Ω~40.00MΩ	0.1Ω

DMM mode		
Function mode	Meas. Range	Min. resolution
DCV	600.0mV~20.00V	0.1mV
Frequency	6.000kHz~15.00MHz	1Hz

1.4 Accuracy (Ae) vs. Impedance (Z_{DUT}) @ Ta =18 ~ 28 ℃ (0.5V_{RMS} only)

Freq. / Z	0.1- 1Ω	1 – 10Ω	10 – 100kΩ	100k – 1MΩ	1M – 20MΩ	Remark
DCR	1.5%+5d	0.7%+3d	0.4%+2d	0.7%+3d	1.5%+3d	D < 0.1
100/120Hz	1.5%+5d	0.7%+3d	0.4%+2d	0.7%+3d	1.5%+3d	
1kHz	1.5%+5d	0.7%+3d	0.4%+2d	0.7%+3d	1.5%+3d	
10kHz	1.5%+5d	0.7%+3d	0.4%+2d	0.7%+3d	3.0%+3d	

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 ES51930.
- If test signal amplitude is selected for 0.1V_{RMS}, the accuracy should increased by 50%.

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

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 longer extended cable or probe is used, the guard shielding is necessary.