AN-0003	Charge Resistors for Automated IR Testing
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Init. JRs	

SCOPE

Automated testing of capacitor insulation resistance (IR) with the Danbridge DB620-series megohmmeters often requires a stepwise charging of the capacitor before the actual resistance measurement. This could be due to the fact that the charging time is longer than the time between measurements or to secondary effects like "dielectric absorption" of foil capacitors. The later makes it necessary to ensure that the capacitor is fully charged before measurement. This application note describes the fundamentals of calculating the charge resistor values.

GENERAL

Fig. 1 shows the set-up for a DB622/623 Megohmmeter with two HT supplies, one for pre-charging and one for fine charging and measurement.

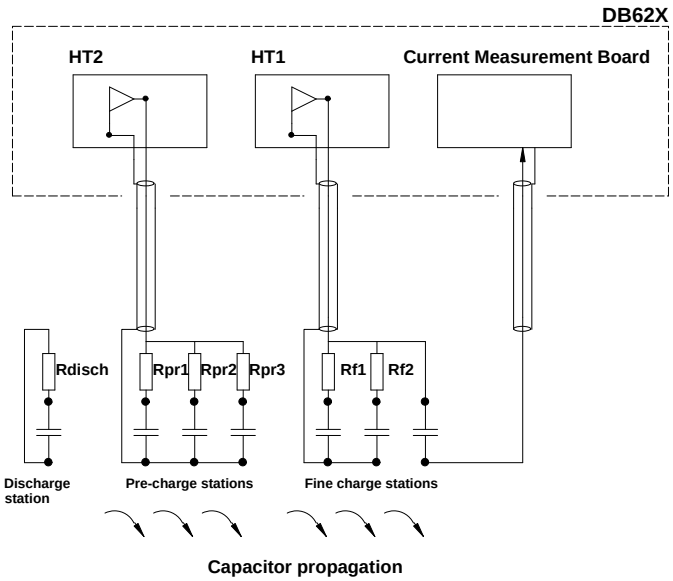

Fig. 1: Example of IR testing set-up.

Normally, there is more than 3 precharge and more than 10 fine charge stations, but for simplicity the number is reduced. In the example there is three precharge stations and two fine charge stations before the measure station. The precharge stations perform the bulk charging of the capacitors. The purpose of the fine charge stations is to ensure that the capacitor is charged to the exact test voltage. The capacitors propagate stepwise from one charge station to the next. The resistors must be placed near to the charge station. When a capacitor is connected to the first precharge station it is charged by both HT2 and the other capacitors connected to HT2.

IF THE IR MEASUREMENT HAS BEEN PRECEDED WITH A HIGH VOLTAGE ISOLATION TEST ("FLASHTEST") A DISCHARGE STATION SHOULD ALWAYS BE USED BEFORE THE PRECHARGE STATIONS.

If the capacitor is not discharged before entering the precharge stations it could lead to destruction of the HT2 due to over voltage or to IR measurement error.

R_{Pr1} is limiting the charge current to protect the capacitor and the surrounding equipment. The value is calculated from:

$$R_{\mathrm{Pr1}} = \frac{U_{HT}}{I_{C,\max}} \qquad [1]$$

ALWAYS USE A SERIES RESISTOR AT THE FIRST CHARGE STATION.

The maximum allowable current is usually much larger than the current limit of the HT supplies. However, due to the charge stored in the HT output filter, cables etc. a very large current could flow into the capacitor creating electronic transients destructive to both capacitor and electronic equipment.

TESTING FOIL CAPACITORS

For precharging foil capacitors with dielectric absorption it is assumed that the capacitor is charged to the full test voltage already at the first station. The first resistor is given by [1], the last resistor (R_{Pr3} in fig. 1) should match the following fine charge resistors (see later). The intermediate (R_{Pr2} in fig.1) resistors should have values between 10-20 times R_{Pr1}.

The fine charge resistors should match the input resistance Ri of the current input amplifier. In the DB620-series Megohmmeters this resistor can be switched to either 10kohm or 1Mohm. In fig 1 only two fine charge stations are shown, in many cases more than 10 stations are to be preferred.

Example: (Fig. 1) C=2.2uF $I_{C,max}$=1A U_{HT}=500V R_i=1Mohm

R_{Pr1} = 500V/1A = 500ohm R_{Pr2} = 10*R_{Pr1} = 5kohm R_{Pr3} =R_i = 1Mohm

R_{f1} = R_{f2} = R_i = 1Mohm

TIMING CONSIDERATIONS

To ensure adequate charging of the capacitors the charge times should be calculated. At the first precharge station the series resistor value is normally low, and charge time is basically limited by the HT supply current limit:

$$T_{Ch} = C \cdot \frac{U_{HT}}{I_{Limit}}$$

Example: (Fig. 1) C=2.2uF $I_{C,max}$=1A U_{HT}=500V I_{Limit} = 200mA

T_{ch} = 2.2uF*500V/200mA = 5.5ms

If the HT current limit is higher than the maximum allowable charge current for the capacitor, the charging is exponential with a time constant of:

$$\tau = R_{\mathrm{Pr1}} \cdot C$$

The capacitor should be connected to the first station for a period of at least 3×τ bringing the capacitor voltage up to 95% of U_{HT2}.

Example: (Fig. 1) C=2.2uF $I_{C,max}$=100mA U_{HT}=500V I_{Limit} = 200mA
R_{Pr1} = 500V/100mA = 5kohm
3×τ = 3×5kohm*2.2uF = 3×11ms = 33ms.

RANGE SELECTION

Over the years Danbridge Megohmmeters have been delivered with 3-range and 4 range Current Measurement boards:

600-series:

3-range Current Measurement Boards:	1	1 pA - 10 nA
	2	2 nA - 1 uA
	3	0,2 uA – 1 mA

600- and 620-series:

4-range Current Measurement Boards:	1	1 pA - 10 nA
	2	2 nA - 100 nA
	3	20 nA - 10 uA
	4	2 uA - 1 mA

The correct range is established from measuring the leakage current on several known good and known bad components at the specified voltage and charge/dwell/soak time. The range to choose is the most sensitive range that do not lead to overflow at the upper limit of the leakage current The upper limit is established from the measure voltage divided with the minimum insulation resistance: Ilimit = Uht / IR,min.

Example: U_{HT} = 100V, IR_{min} = 25Gohm => $I_{leak,max}$ = 4nA: Select Range 1.

WIRING AND INSTALLATION IN SORTING MACHINES

When installing the DB62X Megohmmeters and charge resistors in sorting machines great care should be taken in the wiring. The general rule is to avoid electrical loops that can pick up magnetic noise fields (hum) and add self-inductance. Also the effects of flash-overs (sparks) either within the DUT or resulting from mechanical problems like bent component leads have to be considered. If a flash-over occurs the wires to that station act as antennas for the electrical transient. This could lead to disturbances or failures in all electronic equipment in the sorting machine. The problem is aggravated by loops in the wiring from two reasons:

1: The loop acts as an antenna for a magnetic transient influencing the system.

2: Together with stray capacitance in the wiring the self-inductance from the loop forms an oscillating circuit that could amplify the voltage transient.

The best way to protect against flash-overs is to place the charge resistors as close as possible to the charge stations. In this way the transient resulting from the flash-over is damped near the source. However, due to the need for easy replacement of sets of charge resistors many sorting machines have all the charge resistors placed in a box or on a printed circuit board. Fig. 2 shows the schematic of such a system.

The precharge stations are supplied from HT2. The return path of the charge current MUST be the HT2 return and each precharge station MUST have its own return wire. In this way it is possible to ensure parallel wiring of the complete path from the Megohmmeter to each precharge station.

The fine charge stations and the IR test station should be considered as a hole. As for the precharge stations the fine charge stations must have individual return paths and they must have a return path to the HT1 (H.T.). Furthermore, the wiring of the I in connection must be parallel to the wiring of the HT1. This ensures both minimum hum susceptibility and maximum protection against flash-overs. In order to shield the I in connection from capacitively coupled noise the Guard connection should be used all the way to the IR test station. The end of the shield must never be connected to anything but the shield of the I in connector.

Even though there is a demand of easy replacement of charge resistors, it is recommendable to place protection resistors near the charge stations. These resistors should be wirewound types of 2-3W and values of 10-100ohms (for Danbridge order numbers please see bottom of this page).

In sorting machines the chassis is well grounded and the individual parts are well interconnected. This means that the wiring to the test equipment has considerable stray capacitance to earth ground. It is therefore recommendable to have individual mains filters on all test equipment within the sorting machine. The mains filters must be well connected to the chassis near the test equipment. This also minimises influence between measuring equipment, computers, motor controls etc.

Danbridge order numbers for wirewound resistors:

10 ohm	5%	2W	4621000
100 ohm	5%	3W	4632700
1 kohm	5%	3W	4632500

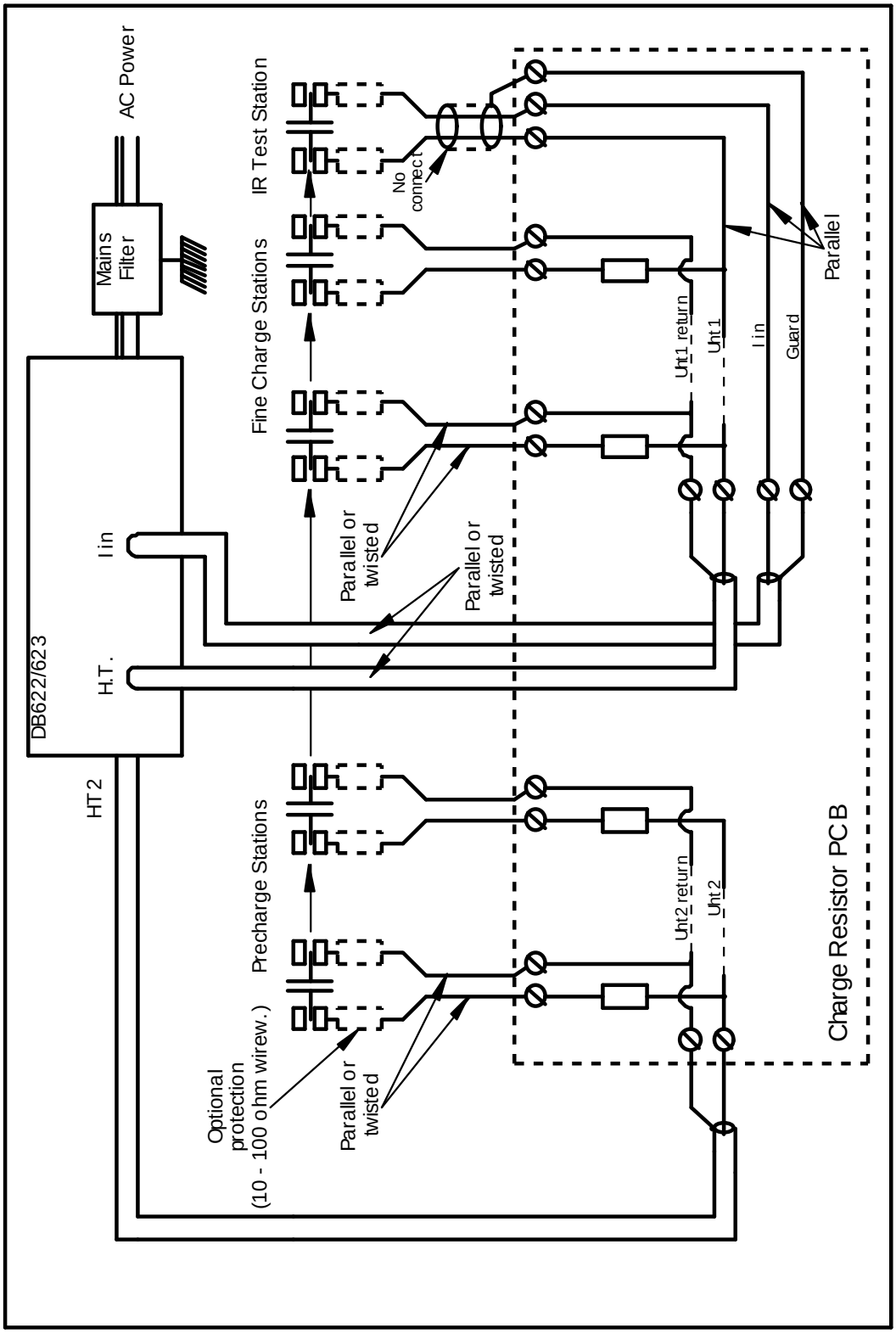

Fig. 2: Wiring of sorting machine.