Model 2300CL
Flicker Calibrator
User Manual

AMETEK®
PROGRAMMABLE POWER

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Important Safety Instructions

Before applying power to the system, verify that your product is configured properly for your particular application.

⚠ WARNING	**Hazardous voltages may be present when covers are removed. Qualified personnel must use extreme caution when servicing this equipment. Circuit boards, test points, and output voltages also may be floating above (below) chassis ground.**
⚠ WARNING	**The equipment used contains ESD sensitive ports. When installing equipment, follow ESD Safety Procedures. Electrostatic discharges might cause damage to the equipment.**

Only *qualified personnel* who deal with attendant hazards in power supplies, are allowed to perform installation and servicing.

Ensure that the AC power line ground is connected properly to the Power Rack input connector or chassis. Similarly, other power ground lines including those to application and maintenance equipment *must* be grounded properly for both personnel and equipment safety.

Always ensure that facility AC input power is de-energized prior to connecting or disconnecting any cable.

In normal operation, the operator does not have access to hazardous voltages within the chassis. However, depending on the user's application configuration, **HIGH VOLTAGES HAZARDOUS TO HUMAN SAFETY** may be normally generated on the output terminals. The customer/user must ensure that the output power lines are labeled properly as to the safety hazards and that any inadvertent contact with hazardous voltages is eliminated.

Guard against risks of electrical shock during open cover checks by not touching any portion of the electrical circuits. Even when power is off, capacitors may retain an electrical charge. Use safety glasses during open cover checks to avoid personal injury by any sudden component failure.

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SAFETY SYMBOLS

Symbol	Description	Symbol	Description
⚠	WARNING Risk of Electrical Shock	⚠	CAUTION Refer to Accompanying Documents
○	Off (Supply)	⎓	Direct Current (DC)
⏻	Standby (Supply)	∼	Alternating Current (AC)
|	On (Supply)	3∼	Three–Phase Alternating Current
⏚	Protective Conductor Terminal	⏚	Earth (Ground) Terminal
⏛	Fuse	⏛	Chassis Ground

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The Buyer will, at its expense, return the defective Product or parts thereof to AMETEK in accordance with the return procedure specified below. AMETEK will, at its expense, deliver the repaired or replaced Product or parts to the Buyer. Any warranty of AMETEK will not apply if the Buyer is in default under the Purchase Order Agreement or where the Product or any part thereof:

- is damaged by misuse, accident, negligence or failure to maintain the same as specified or required by AMETEK;
- is damaged by modifications, alterations or attachments thereto which are not authorized by AMETEK;
- is installed or operated contrary to the instructions of AMETEK;
- is opened, modified or disassembled in any way without AMETEK's consent; or
- is used in combination with items, articles or materials not authorized by AMETEK.

The Buyer may not assert any claim that the Products are not in conformity with any warranty until the Buyer has made all payments to AMETEK provided for in the Purchase Order Agreement.

PRODUCT RETURN PROCEDURE

1. Request a Return Material Authorization (RMA) number from the repair facility (**must be done in the country in which it was purchased**):

   - **In the USA**, contact the AMETEK Repair Department prior to the return of the product to AMETEK for repair:

     Telephone: 800-733-5427, ext. 2295 or ext. 2463 (toll free North America)
     858-450-0085, ext. 2295 or ext. 2463 (direct)

   - **Outside the United States**, contact the nearest Authorized Service Center (ASC). A full listing can be found either through your local distributor or our website, www.programmablepower.com, by clicking Support and going to the Service Centers tab.

2. When requesting an RMA, have the following information ready:

   - Model number
   - Serial number
   - Description of the problem

NOTE: Unauthorized returns will not be accepted and will be returned at the shipper's expense.

NOTE: A returned product found upon inspection by AMETEK, to be in specification is subject to an evaluation fee and applicable freight charges.

Table of Contents

List of Figures

List of Tables

1 Introduction

This instruction manual contains information on the installation, operation, calibration and maintenance of all power systems that use the 2300CL Flicker Calibrator.

The 2300CL Flicker Calibrator generates precise voltage fluctuation (flicker) levels (expressed in P_{st} and P_{lt}), and also permits the user to check a flickermeter's performance for the directly measured parameters called d_c, d_{max}, and d_t. This allows verification of conformance to the EN61000-3-3/11 flicker test standard.

The 2300CL may also be used as a resistive load in combination with a California Instruments iX Series AC power source to generate different levels and combinations of harmonic currents. These harmonic currents can then be measured by the EN 61000-3-2 Harmonics Test system for verification of its performance. Waveforms for this purpose are provided as part of the CLGUI Windows™ GUI software for download to the iX Series AC power source.

Finally, the flicker calibrator allows the user to verify the accuracy of any reference impedance being used in a flicker test system. The instrument can also be used to measure system impedance as it allows the user to apply a precisely known loads, and check the voltage drop due to this load.

1.1 Principle of Operation

The flicker calibrator consists of a number of calibrated, purely resistive loads, which can be modulated on/off via solid state switches at a user selected square wave modulation frequency for the purpose of P_{st} and P_{lt} calibrations. This method is in exact conformance with the rectangular modulation as defined in EN60868, Table 9-1, and Table 9-2 (flicker meter performance checkpoints). In d_t calibration mode, the flicker calibrator can be turned on for just 0.5 - 1.5 cycles and then off for several seconds, and then repeat this pattern using a suitably programmed function generator. Finally, the load may be turned on for 10 seconds and then off for 10 seconds for d_c calibration.

Modulation for P_{st} levels from 0.45 — 7.25 can be selected in 5 calibrated steps. This corresponds to voltage fluctuations from 0.125 - 2.00% at the critical modulation frequency of 8.77 Hz. At other modulation frequencies, the modulation levels correspond to lower P_{st} values as given in the table.

The calibrator may be used to verify operation of stand-alone flickermeters as well as integrated compliance test systems such as the California Instruments CTS.

1.2 Front Panel Operation

The 2300CL can be completely operated from the front panel using simple push button controls. To perform a flicker calibration, additional equipment is needed. The selected setting on the 2300CL is indicated using lighted push buttons.

Figure 1-1: Model 2300CL AC Load

The are no displays on the front panel of the 2300CL, but there are outputs that may be used to monitor the modulation signal or measure the load current using the built-in precision current transformer.

Additional calibration and verification functions can be performed with the 2300CL when used in combination with a California Instruments iX Series AC power source. Special Windows Application software (CLGUI) is provided for this purpose.

2   Specifications

All specifications are for a single 2300CL chassis at 23° ± 5° C.

2.1 Included With Each 2300CL Series System

- Instruction / Programming Manual
- Windows™ Graphical User Interface (CLGUI)
- AC Line cord

2.2 Mains Input

Line Voltage:	100 to 240 VAC ±10%
Line VA:	150 VA max
Line Current:	1.5A rms max
Line Frequency:	50 - 60 Hz ±10%
Isolation Voltage:	1350 VAC input to chassis

2.3 EUT Input

Max. Peak power:	2300 W
Current:	20A RMS
Max. Peak current:	30 A
Voltage:	300V RMS
Isolation Voltage:	1350 VAC EUT input to chassis

2.4 Protection

EUT Over Current	Fuse, 20 A
Over Temperature	Thermal shut down.

2.5 Regulatory

Electromagnetic Emissions and Immunity:	CE
Acoustic Noise:	65 dBA @ 1 meter
Safety:	EN61010

2.6 Modulation Levels

Resistor Values:	
Modulation Levels	Resistor values of the 2300CL are set to provide the voltage modulation levels shown here when 230 Vac is applied to the 2300CL. For different voltage levels, the modulation settings will have to be scaled.
Pst Switch	Resistance (± 1 %)
0.125	319.6 ohms
0.250	159.6 ohms
0.500	79.6 ohms
1.000	39.6 ohms
1.750	22.46 ohms
IMP CHK	0.55 ohms
	Note: Do not apply more than 5 V RMS when using this setting

2.7 Front Panel Controls

Controls:	
Modulation Level Selection Buttons	This is a group of six interlocking push buttons that are used to select the modulation depth. The actual P_{st} level that results from this selection is also a function of the modulation frequency programmed on the function generator. The values shown above these keys are the modulation depths in percent for a 230 V nominal voltage. The button marked IMP CHK is used to check calibration of power source programmable impedance.
PST	Mode select button
DC	Mode select button
DC Test	Push Button
Indicators:	
Power:	Indicator for AC power input.
Over Temp	Red lamp indicates over temperature shutdown.

2.8 Connectors

Inputs:	
Line input (rear panel)	IEC 320
EUT Input (rear panel)	Kulka Terminal Block, L - N from AC Source or PACS-1/3
Function Generator (rear and front panel)	BNC
Outputs:	
CT Output (rear and front panel)	Dual Banana
Counter Output (rear and front panel)	BNC

2.9 Dimensions, Weight, Environmental

Height:	7" (17.8 cm) excluding feet 7.6" (19.3 cm) including feet
Width:	19" (48.3 cm)
Depth:	22" (55.9 cm)
Weight:	45 lb (20.4 kg) net 55 lb (25 kg) shipping
Vibration and Shock:	NSTA 1A transportation levels.
Cooling:	Forced air, dual fans. Side and bottom intake, rear exhaust. Rear panel clearance must be at least 6" (15 cm)
Operating Temperature:	0 - 40 °C
Storage Temperature:	-20 - 80 °C
Altitude:	<2000m
Relative Humidity:	80% maximum for temperatures up to 31 ºC decreasing linearly to 50% relative humidity at 40 ºC
Installation/Overvoltage Category:	II
Pollution Degree:	2
Indoor Use Only	

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3   Unpacking and Installation

3.1 Unpacking

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. **DO NOT** return an instrument to the factory without prior approval. Do not destroy the packing container until the unit has been inspected for damage in shipment. See Section 0 for information on service returns.

> ⚠ **WARNING: This product weighs 40 lb (18 kg). Rack handles are for sliding the unit in and out of instrument racks and are not designed for lifting the unit. Obtain adequate help when moving or mounting the unit.**

3.2 Power Requirements

The 2300CL Flicker Calibrator has been designed to operate from a single-phase 115 or 230 volt AC line.

3.3 Mechanical Installation

The 2300CL is a completely self contained flicker calibration load. It may be used free standing on a bench top or rack mounted. The 2300CL Flicker Calibrator is fan cooled, drawing air in from the sides and bottom and exhausting at the rear. The sides of the unit must be kept clear of obstruction and a 6" (15 cm) clearance must be maintained to the rear. Special consideration of overall air flow characteristics and the resultant internal heat rise must be allowed for with systems installed inside enclosed cabinets to avoid self heating and over temperature problems.

For rack mount applications, the -RMS option slides are required unless the end-user provides another mean to support the unit in the instrument rack. The rubber feet at the bottom of the unit should be removed for rack mount installation. They are intended for bench top use only.

3.4 AC Line Cord

The AC line input IEC connector is located at the rear of the unit. A standard equipment power cord must be used to connect the calibrator to line power The AC line input fuse is located at the rear panel of the unit. A standard US line cord and a universal 'pig-tail' line cord, which can accept a country specific AC plug, are included with each unit.

3.5 Rear Panel Connections

The rear panel (see Figure 3-1) provides connectors for input power, the load connection, oscilloscope outputs - allowing the user to visualize the load modulation and the external modulation input. The flicker calibrator can be operated from either 115 V or 230 V single phase line voltage (50/60 Hz) and requires less than 60 watts operating power.

The flicker calibrator is connected (via the EUT INPUT terminal block located on the rear panel) to an appropriate voltage source (normally 230 V - 50 Hz). The connector style for the EUT INPUT (terminal block) was deliberately selected to be different from the input power connector, in order to avoid possible misconnection.

Because the calibrator may generate a considerable amount of internal heat, two cooling fans are required to maintain a safe operating temperature. The airflow intake for these fans should not be obstructed. Air flows from the sides and bottom through the unit, and exhausts in the rear. Therefore, the calibrator should have at least a 6" (15 cm) clearance at the back, to ensure proper cooling air flow.

The output connectors labeled COUNTER OUTPUT and CT OUTPUT allow the user to connect an oscilloscope or counter and DVM's and a counter respectively, to verify proper operation of the system. The CT OUTPUT accurately reflects the real-time current waveform, and allows the user to observe the (modulated) signals. The COUNTER OUTPUT reflects the modulation frequency square wave.

To control the modulation level, a separate square wave modulation frequency source must be used. The modulation signal must be applied to the BNC connector labeled FUNCTION GENERATOR INPUT. This input requires a square wave TTL level signal with a 50% duty cycle. The minimum input level is between 0 and +4 Vpeak, the maximum is between 0 and +30 Vpeak.

3.5.1   EUT Wiring

The equipment under test (EUT INPUT) connector is located at the rear of the unit. The EUT input power cable diameter (gauge) must be large enough to prevent as much voltage drop as possible between the power source and the load. Cable lengths between the EUT and the 2300CL must be kept as short as possible and should never exceed 2 feet (61 cm).

Figure 3-1: 2300CL Rear Panel

4 Calibration Functions

The flicker calibrator may be used to perform P_{st}/P_{lt}, as well as d_t - d_c and d_{max} calibration. The desired calibration function is selected via front panel push buttons. Also, the desired fluctuation level is selected via push buttons. Finally, the modulation frequency must be provided using an external square wave function generator.

4.1 CTS Compliance Test System Verification

To calibrate flicker test systems such as California Instruments CTS systems, the 2300CL is used as the CTS system load. The EUT INPUT on the back of the 2300CL is connected to the CTS output terminals in the back compartment of the PACS or to the "Schuko" outlet on the front panel of the PACS. The system connection is shown in Figure 4-1.

Note that the calibrator should be operated for at least 5 minutes prior to starting any calibration.

If the unit was stored at temperatures below 15 $^\circ$C, the calibrator should be operated for at least 15 minutes. The following preparatory steps are required prior to performing a flicker calibration.

After the unit is turned on, verify the presence of the correct AC voltage on the 2300CL input using a DVM. Also check to see if current flows through the load using the CT OUTPUT monitor. Set the modulation frequency of the load using a function generator and select either the P_{st} or d_c function.

The P_{st} calibration function is selected via the PST selector switch. The modulation level is selected by pressing the appropriate level switch. Set the level to 0.50%. The selected push buttons will be lighted. Adjust the modulation frequency to read about 8.77 Hz. Next, select the d_c function and use the DC button to apply the load 10 seconds on, 10 seconds off.

Via the CTS system software, the output power to the 2300CL needs to be applied in order for the flicker calibrator to present a load to the system. Also, a flicker test has to be started in order to have the reference impedance of the CTS present in the circuit. Of course, the CTS software needs to be configured for the appropriate hardware combination. It is important that the reference impedance of the CTS system be used (either programmable impedance or lumped impedance).

Assuming that the CTS test voltage is set to 230 VAC, the DVM current measurement reading should vary between a residual reading of about 20 mA to a level of ~ 2.88 Arms. If the test voltage differs from 230 VAC, the current should be proportionately different as well. It is not necessary for the test voltage to be exactly 230.00V rms. A reading between 229.50 and 230.50 is acceptable. In d_c mode, when the load is turned on for about 10 seconds the current is 2.88 amps. When the load is off for 10 seconds the current is ~ 20 mA. If both voltage and current readings are verified to be correct, the CTS display system should respond with a d_c reading of ~0.50%. Selecting different percentage settings such as 0.25 or 1.00% should result in corresponding d_c readings. Note that smaller power sources like the 1251RP and 2000RP cannot support the highest modulation settings. For example a 2% modulation is not supported by the 2001RP because this requires a current level greater than 11 Arms. If the d_c readings of the CTS correspond to the selected values on the calibrator, the overall system setup is correct. If the d_c readings do not correspond to the selected values, it is necessary to verify the CTS configuration, including the reference impedance section. Pay particular attention to possible voltage drops occurring in the cabling between the AC source and the PACS or the PACS and the 2300CL. Cable lengths should be short and sufficient wire gauge size should be used to carry 15 amps.

For CTS versions with either the 1251RP or the 2000RP, the reference impedance is normally included in the PACS signal-conditioning unit. For CTS configurations with an iX power source,

the system normally uses the programmable impedance in the power source, although there are iX versions of the CTS that include an external impedance unit (called OMNI). With the reference impedance in place, the current of 2.88 amps will produce a voltage drop of 1.15V rms (0.5% modulation level for a nominal level of 230 VAC) through the IEC-725 reference impedance. Thus, the voltage reading via the CTS and an NIST traceable DVM should indicate this voltage drop (percentage) each time the load is turned on in d_c mode. Provided the meters confirm proper operation, the system is now ready to run a flicker calibration verification.

4.2 P_{st} Calibration

The most demanding P_{st} (short term Flicker level) calibration point is at 1052 voltage changes per minute (CPM). At this frequency, a rectangular voltage fluctuation of only 0.276% represents a P_{st} level of 1.00 (see modulation Table 9-1 on page 39 and Figure 4-2 on page 11). The P_{st} level of 1.00 is the failure limit for electrical devices tested per IEC61000-3-3 and represents the "light flicker irritation threshold" for the average human. Figure 4-2 shows the human perceptibility curve, i.e., the voltage fluctuation level vs. modulation frequency that results in a P_{st} equal to 1.00. The P_{st} level at any given frequency is proportional to the voltage fluctuation, hence a voltage change of 0.25% @ 8.77 Hz would result in a P_{st} level of 0.25/0.276 = 0.906.

The overall accuracy of a flickermeter is required to be better than +/- 8%. Thus a flicker level of 0.91 must always result in a "PASS" for the test. The intermediate flicker level called P_{sti} is calculated over a 10 minute observation period, and 12 each successive P_{sti} values are used to

R_A = 0.24 Ohm X_A = j 0.15 Ohm

R_N = 0.16 Ohm X_N = j 0.10 Ohm
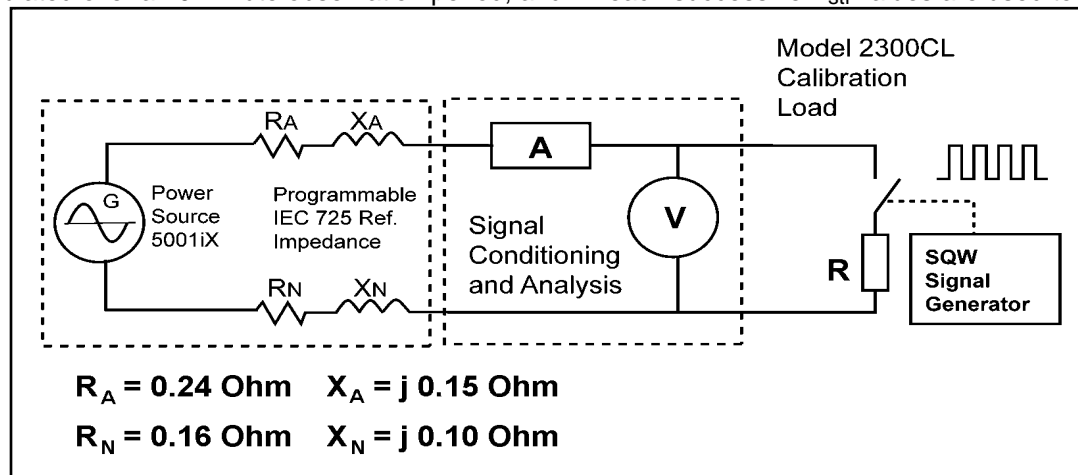
Figure 4-1: Flicker Meter Calibration Setup Diagram

compute the long term Flicker level P_{lt}.

Some flickermeters such as the California Instruments CTS display the instantaneous P_{st} level, which is continuously updated (every second). When using the precisely determined rectangularly modulated signal, the instantaneous P_{st} level quickly approaches its P_{sti} value for modulation rates greater than 5 changes per minute. Thus, the intermediate P_{st} value over approximately 2 minutes (12,000 half cycles of the 50 Hz signal) will be very close to the statistics that will result after the full 10 minute test (60,000 samples of the 50 Hz half sine values).

Therefore, the proper operation of flicker compliance test systems such as the California Instruments CTS can be checked within minutes, although a formal calibration process should be run for 10 minutes (P_{st}) or 2 hours (P_{lt}). Furthermore, complex voltage change patterns can be run under computer control. These flicker tests can run over any period to cover all the

possible range/modulation frequencies of interest, and to verify multiple intermediate P_{sti} levels, along with successive 2 hour P_{lt} levels.

The IEC61000-3-3 standard requires flicker to be measured within an overall error < +/- 8%. This overall error includes reference impedance inaccuracies, system wiring, source voltage, and flicker calculation errors. The flickermeter by itself therefore should measure P_{st} within +/- 5%, in order to allow some tolerance for the Reference Impedance. To run a P_{st} calibration, the user selects the desired modulation percentage on the front panel and sets the frequency using the function generator. The P_{st} function must be selected as well by using the front panel controls. A counter or oscilloscope and DVM may be used to verify proper operation, and to confirm that the load is modulated as desired.

Figure 4-2: Flicker Perceptibility Curve
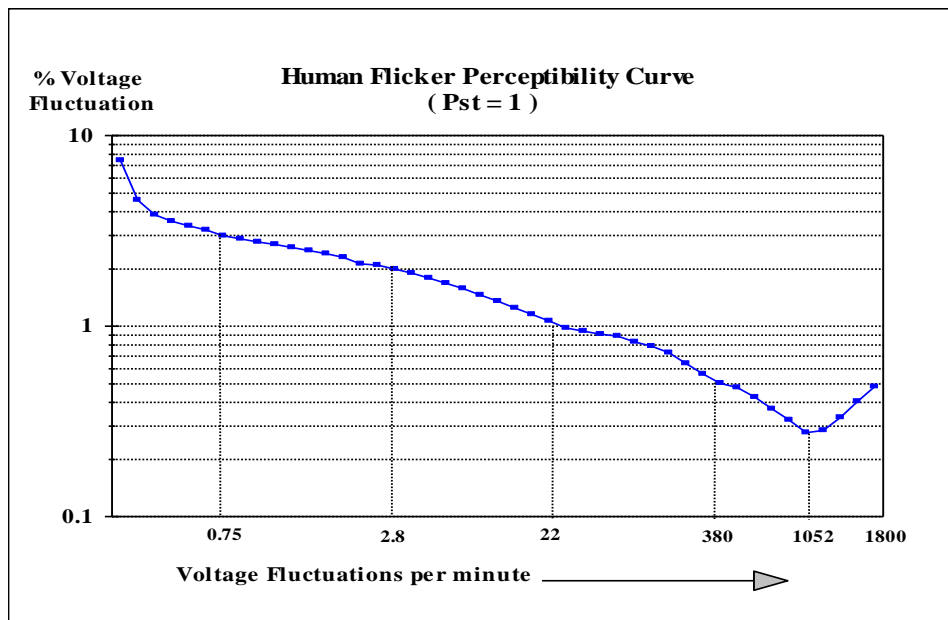
4.3 d_c-d_t Calibration

As mentioned earlier, the calibrator also has d_c and d_t calibration functions. In d_c mode, the calibrator can be used to apply the selected load level (d_c/d_t level) by pressing the DC push button for approximately 10 seconds, and then releasing it for the same duration. The flickermeter therefore should indicate the selected d_c level.

In d_t calibration mode, the calibrator may be used to produce a short load modulation from 10 - 30 milliseconds long that repeats every 1.5 - 2 seconds. A suitable function generator capable of producing such a control signal must be used to accomplish this function. In this mode of operation, a flickermeter should indicate the proper d_t (and d_{max}) levels, without changing the d_c indication.

5   Front Panel Operation

5.1 Tour of the Front Panel

The following indicators and controls are available on the front panel:

5.1.1   Front Panel Controls and Indicators

- Power On/Off switch
- Power On indicator (lamp)
- Modulation Level select switches (5)
- PST/DC Mode select switches (2)
- DC Test push button
- Over temperature indicator (lamp)

5.1.2   Front Panel Inputs and Outputs

- CT Output. This dual banana jack output generates a voltage equivalent to the load current. The output signal level is 100 mV/A.
- Counter Output. This BNC output provides the signal generator signal supplied to the Function Generator Input for monitoring purposes.
- Function Generator Input. This BNC accepts a square wave signal used to modulate the load with a specific frequency.
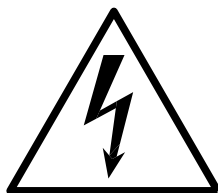
CAUTION

HIGH VOLTAGES MAY BE PRESENT IN CERTAIN SECTIONS OF THIS PRODUCT. THIS EQUIPMENT GENERATES POTENTIALLY LETHAL VOLTAGES.

DEATH

ON CONTACT MAY RESULT IF PERSONNEL FAIL TO OBSERVE SAFETY PRECAUTIONS. DO NOT TOUCH ELECTRONIC CIRCUITS WHEN POWER IS APPLIED.

6   Calibration

The Routine Calibration should be performed every 12 months. Non-routine Calibration is only required if a related assembly is replaced or if the periodic calibration is unsuccessful.

6.1 Calibration Equipment

Digital Multimeter: Fluke 8506A / HP 34401A or equivalent

10 milliohm current shunt: Isotek Model RUG-Z-R010-0.1 or equivalent

6.2 Calibration Setup

The 2300CL load resistance values must be verified annually using two precision DMM's. Since the current needs to be measured for this purpose, the current transformer of the 2300CL should be verified first using an external current shunt or CT and DMM of suitable accuracy. (0.1 % or better). Refer to the instrumentation setup in Figure 6-1 on the next page.

Once the 2300CL current transformer output has been verified, the resistor values can be checked using the following procedure. The resistor values cannot be adjusted so this is a verification procedure only.

- Connect the output AC Power Source into the calibrator power input on the rear panel of the 2300CL.

- Program the AC Power Source 230VAC and turn the 2300CL on/off switch on.

- Select each of the Amplitude Modulation switches. The light will come on to represent the switch you have selected.

⚠ *WARNING: Make sure the 2300CL DC switch is on (not the Pst switch)*

- Push the HOLD button to close the 2300CL circuit. This will engage the selected resistance setting. Check voltages and current to calculate the resistance.
  Voltages ÷ I current = Resistance

REF SWITCHES	PROGRAM VOLTAGES VAC	MONITOR CURRENT I CURRENT (A)	RESISTANCE ± 1% (Ω)
0.125	230.0	0.718	319.6
0.250	230.0	1.437	159.6
0.500	230.0	2.875	79.6
1.000	230.0	5.750	39.6
1.750	230.0	10.314	22.46
IMP CHK *	5.0	8.712	0.55

* Note that the IMP CHK check requires the AC Source voltage to be set to only 5V rms

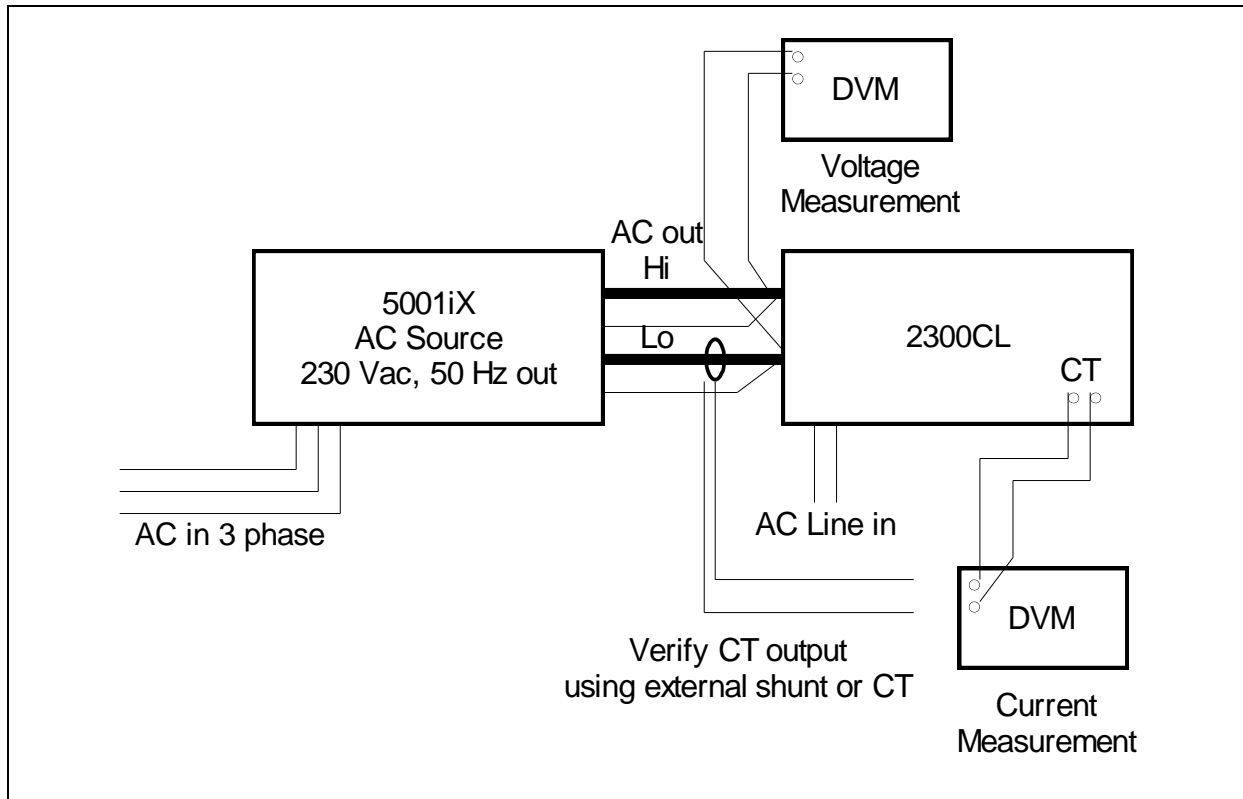*Table 6-1: Resistor Values for the 5 Pst Settings*

Figure 6-1: 2300CL Calibration Setup

6.3 2300CL Flicker Calibrator Accuracy Verification

For the accuracy verification, the 2300CL is operated in the "dc" test mode. In "dc" test mode, the 2300CL allows current flow when the user pushes/holds SW-8 (the "dc" test button). The current level is dependent on the supply voltage level, and which resistance portion of the 2300CL is activated (selected by switch SW-1 through SW-5). By measuring the applied voltage and current flow through the 2300CL, this test may be used to verify the accuracy of the load resistor value for each of the 5 switch settings (0.125 – 0.25 – 0.50 – 1.00 – 1.75 %). The test can include the full CTS verification (5001ix-CTS), or include just the 2300CL.

$R_A = 0.25\ \Omega$ $X_A = j0.15\ \Omega$
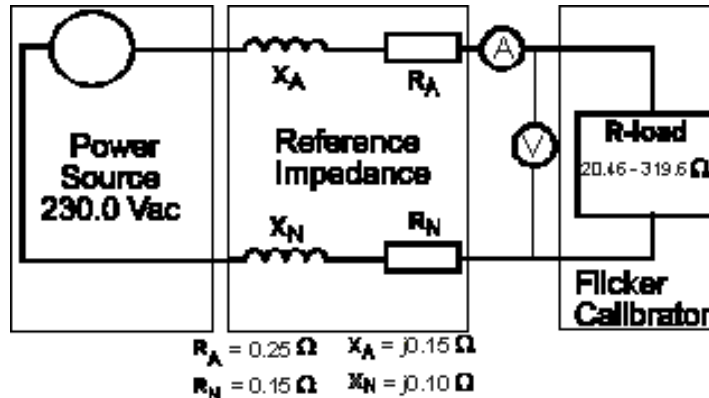$R_N = 0.15\ \Omega$ $X_N = j0.10\ \Omega$

Figure 6-2: Test Setup with CTS System

To verify both the CTS and the 2300CL, the test circuit includes either a PACS (signal conditioner of the CTS) with internal LR-1 reference impedance, an external Reference Impedance (OMNI), or the iX output impedance programmed to the IEC-60725 reference values of 400 milli-Ohm, and 798 μ.. For systems using an OMNI or a PACS with internal LR-1, the output impedance of the "iX" must be set to the minimum values possible. The 5 test steps below are used to verify accurate operation for each of the 5 levels (see above figure).

As a function of the current level through the impedance (the LR-1, external OMNI or programmed ix impedance) a proportional voltage drop will occur within the impedance. This voltage drop will result in a lower input voltage at the 2300CL terminal block (as compared to the source output voltage). The expected values in the table below will result if the impedance value and the 2300CL resistance are correct. Proper operation of the 2300CL is determined by the correct current readings, but if the voltage readings deviate more than +/- 0.2 Volt from the levels in the Voltage column, either the reference impedance or the 2300CL resistance values need to be adjusted.

DC level Switch setting	Desired Current reading A rms	Min – acceptable reading A rms	Max. acceptable reading A rms	Voltage level at 2300CL input
SW-1	0.719	0.712	0.726	229.7
SW-2	1.438	1.424	1.452	229.4
SW-3	2.875	2.846	2.904	228.9
SW-4	5.750	5.693	5.808	227.7
SW-5	10.063	9.962	10.164	226.0

It is also possible to test the 2300CL without any other impedance in the circuit. For this test, the voltage at the 2300CL input terminals and the current going into the 2300CL is measured. It is important to verify

that the (source) voltage during this test is not distorted, because distorted voltages may affect the measurement accuracy. Furthermore, the supply voltage must be provided by a non-inductive source, so that the overall power factor is near unity (0.999 - 1.000). The voltage and current measurements can then be performed using a high accuracy RMS meter, and the readings can subsequently be used to compute the 2300CL resistance values in each setting. The resistance values given in the table below (+/- 1 %) should be present. The test setup is illustrated below.
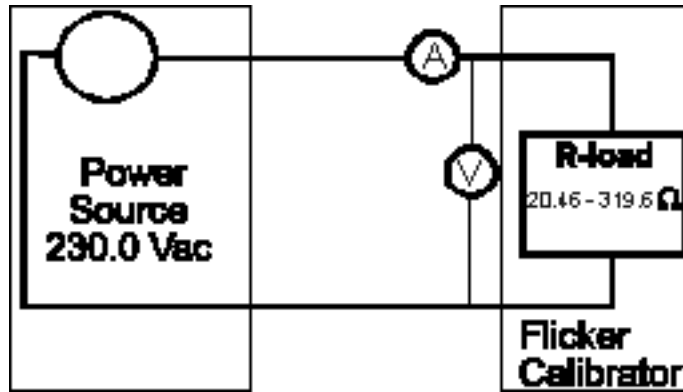
Figure 6-3: Test Setup with AC Source

DC level Switch setting	Desired Resistance max. permitted tolerance is +/- 1 %
SW-1	319.60
SW-2	159.60
SW-3	79.60
SW-4	39.60
SW-5	22.46

Table 6-2: Resistance Values

7 Service

7.1 Cleaning

The exterior of the 2300CL Flicker Calibrator may be cleaned with a cloth dampened with a mild detergent and wrung out. Disconnect all power to the 2300CL before cleaning. Do not spray water or other cleaning agents directly on the unit.

7.2 Symptoms

7.2.1 No Load Current When Voltage Applied

Make sure the correct mode is selected and a signal generator is connected to the Function Generator Input BNC at either the front or rear of the 2300CL.

Check the signal generator signal for proper signal level (0 to 4 Vpeak minimum).

Check the load current fuse. This fuse will blow when the load current exceeds 20 Arms. If blown, remove any overload condition and replace fuse with identical type and rating.

7.2.2 Over Temp LAMP Lit

This LED is lit when the internal heat sink exceeds 100 °C. The load is automatically disconnected when this condition occurs to prevent damage. Allow more and cooler air to flow through the load. If the load is clogged with dirt, vacuum the dirt out. When the unit cools down sufficiently, the LED will go out and the load will turn back on.

• Verify the status LED is blinking on the rear panel.

7.3 Repair Procedure

In the unlikely event that the flicker calibrator needs to be returned for repair or service, contact your local California Instruments representative from whom you purchased the instrument.

If no local service center is available, the unit may be shipped back to the factory using suitable packaging. Before returning a unit to the factory, you must obtain a Return Material Authorization (RMA) number. You can request an RMA number by fax or email using the following data:

Fax: + 1 858 677 0940

Email: support@calinst.com

Once you have received an RMA number, use the following shipping address to return the instrument for service:

California Instruments Corporation.
Attention: Customer Service
9689 Towne Centre Drive
San Diego, California 92121-1964
United States of America

7.4 Replaceable Parts

In order to ensure prompt, accurate service, please provide the following information, when applicable for each replacement part ordered.

a. Model number and serial number of the instrument.

b. California Instruments' part number for the sub-assembly where the component is located. (California Instruments PART #)

c. Component reference designator. (SEQ #)

d. Component description.

e. Component manufacturers' FSCM number. (VENDOR)

All replaceable part orders should be addressed to:

> **California Instruments Corporation.**
> Attention: Customer Service
> 9689 Towne Centre Drive
> San Diego, California 92121-1964
> United States of America

Orders may be placed by fax using the fax following fax number:

> +1 858 677 0940

CI PART #	DESCRIPTION
Contact Factory for replacement part numbers	
241183	Fan, 6"/15.24cm , 24VDC
270156	Fuse, 3A, 250V
270167	Fuse, 20A, 250V
250493	Lamp, Neon, Amber, 250V
250519	Lamp, LED Green
240547	Switch, Rocker, DPDT
250063	Lamp, Incandescent, 12V, .04A
250733	Lamp, T-1 3/4 Bi-Pin Base
250734	Lamp, T-1 3/4 Midget Flange Base

Table 7-1: Replaceable Parts

LOCATON	DESCRIPTION
Line Input (rear panel F1)	T3A, 250V (CI# 270156)
EUT Input (rear panel F2)	T20A, 250V (CI# 270176)
A1 power supply F1	T800mA, 250V (Wickmann TR5)
A2 power supply F1	F3.15AH, 250V (Littelfuse 216 3.15)

Table 7-2: Fuses

8   CL GUI Installation

8.1 Introduction

CL-GUI is a utility program designed to facilitate several tasks common to verification of CTS performance.

8.2 CLGUI Program Requirements

To successfully install and operate the CLGUI program, you will need the following equipment:

- California Instruments 2300CL Series Calibrator

PC capable of running Windows 98™ or Windows NT™

- RS232C communications port
- RS232C serial cable (supplied with the -OP1 option package.) See next section for RS232C cable wiring

    or

- National Instruments IEEE-488 Controller Card

8.2.1   Interface to AC Source

A suitable serial cable to connect the iX Series AC Source to a 9 pin PC-AT style serial port is supplied with the AC Source.

8.3 CLGUI Setup and Installation

This section covers installation of the CLGUI from the distribution disk to the user's PC. Make sure the PC is capable of running Windows with at least 64 Mbytes of memory and 4 Mbytes of available hard disk space.

8.3.1   Connecting the AC Source to the PC When Using RS232

Connect the iX Series AC Source to the PC using a straight through RS232C cable.

Required AC Load com port settings to work with the CLGUI are as follows:

Baud rate: 38400 baud
Data bits: 8
Stop bits   1
Parity bits: none
Handshake: Hardware

8.3.2   Connecting the AC Load to the PC Using IEEE-488

Connect the AC Load to the PC using an IEEE-488 interface cable. A National Instruments GPIB controller card is required to use the CLDGUI program over IEEE-488. Set the desired IEEE address using the GPIB/RS232 SETUP menu.

8.3.3 Installing the CLGUI Software

The CLGUI software is distributed on CD-ROM. The CLGUI must be installed from this CD-ROM using the included setup program as all required files are compressed. You cannot copy the contents of these diskettes or CD to your PC hard drive and run the program. To install the CLGUI, proceed as follows:

1. Turn on the PC and boot up in Windows™

2. Insert the CD-ROM in your CD-ROM drive.

3. From the Windows Start Menu, select RUN.

4. At the "Open" prompt, type D:Setup or, depending on which disk drive you used the correct drive letter and click on the OK button. If you are installing from CD ROM, locate the sub directory called CLGUI on the CDROM and run the setup program located in this directory.

5. Follow the instructions provided by the setup program to complete the installation. For installations from floppy disks, you will be asked to insert subsequent disks. Remove the present disk and replace it with the next and press OK to continue the installation. Continue through the last disk.

6. When the installation has completed, remove the last disk from the floppy drive and store the disks in a safe place.

Reboot the PC to activate the new settings. You are now ready to start using the CL-GUI software.

8.4 Software Registration

Updates of this and other California Instruments programs are posted on a regular basis on the California Instruments web site. You can find available programs by selecting the Software, GUI's and Drivers menu. To gain access to these downloads, you will need to register as a user on our web site. Instructions on how to register and request the required access level for software downloads, visit our web site at

www.calinst.com

9   CL GUI Operation

9.1 Introduction

CL-GUI is a utility program designed to facilitate several tasks common to verification of CTS performance. It includes five major tasks.

1. Load/transfer an arbitrary waveform to the iX power source.
2. Set up voltage modulation in the iX
3. Perform iX source impedance calculation/calibration/verification
4. Set up harmonics scan on iX
5. Perform flicker calibration.

All five tasks require that an iX type of power source from CI is used and interfaced through either RS232 or GPIB. All five tasks are tied together to within a tab control with task activities of each grouped to within a tab. To establish communication with the power source, do the following:

1. Select the appropriate interface bus on the upper right corner.
2. Optional: Click on the "Show bus" button to bring up a screen where communications with source are displayed
3. Click on the "Establish and verify interface" button.
4. You will be informed if the communication can be established. Once the communication is established, the program will proceed to set up the power source to certain initial stage. The status bar will also display the set up progress. When the source is setup, relevant command buttons will be enabled for you to perform any or all of Tasks 1 through 4.
5. To be safe, CL-GUI will initially turn the source output off. But you may click on the power on/off button to toggle it once the power source control is established.

Once the power source control is established, you have the choice of locking/unlocking the front panel controls. You also have the option to set the source in the high voltage range or let the program decide if the source should be in high or low voltage range. If the source is configured as a three-phase system, you will have the option to select the phase with which the relevant tasks should be performed.

Please note that if you changed the communication interface method after the communication is established you should re-establish the communication first by pressing "Establish and verify interface" button before performing any tasks.

When CL-GUI is running and you launch CTS, the CTS will, as a default, not have source control. You can purposely set the source control option, but please be careful so that CL-GUI and CTS do not use the same interface method.

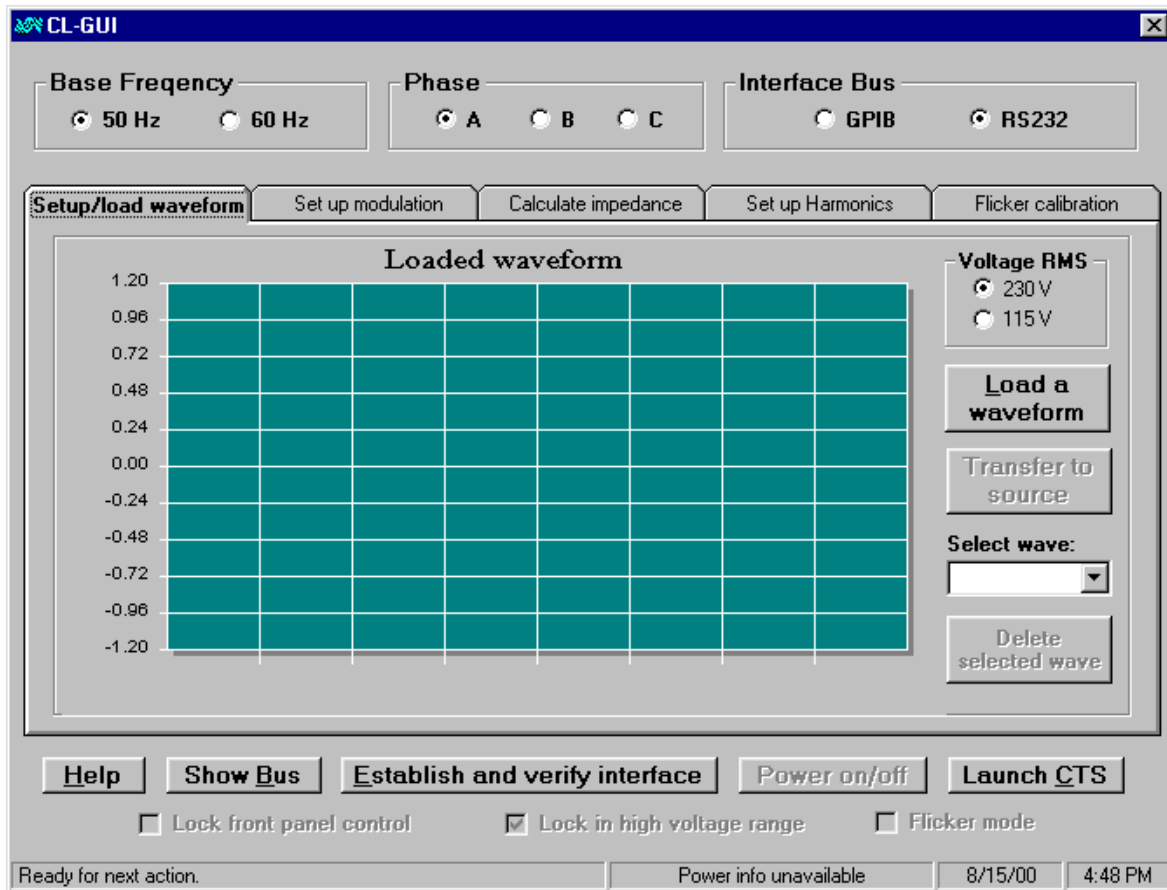## 9.2 Loading and Transferring an Arbitrary Waveform

Figure 9-1: CLGUI Waveforms Tab

There are times that you may wish to run CTS with a specific voltage waveform. For example, you may want to have a current waveform with all the harmonics being at the limits of a particular test class. In this case, you can use a resistive load with a voltage waveform having all the harmonics (and phases). This can be accomplished through Task 1 in the following manner:

1. Click "Setup/load waveform" tab if you are not currently on that tab.
2. Click the "load waveform" button". You will be presented with a list of available arbitrary waveforms
3. Select the one of your choice and click OK. The waveform will be loaded on to the screen.
4. If you are sure this is the waveform you want to have stored in the power source, you can click on the "Transfer to source" button to transfer the waveform to the power source. If the waveform is not right, you can click "Load a waveform" button again to load in a different one.
5. After you click on the "Transfer to source" button, you will be asked to give a name for the waveform. The default is "CAL_WAVE", but you can give a different name. Please keep the filename length to 8 or less. The transfer will take a little time, particularly if the interface is RS232. Once the transfer is complete, the transferred waveform will be selected and the voltage will be set. For some "peaky" waveforms, it may not be possible to set the voltage as desired. This is because to set to the desired voltage RMS value, the peak of the voltage may exceed the voltage limit. In this case, the voltage RMS will be set to the maximum allowable with the give range and a message will be shown of such situation.

You can also delete any of the arbitrary waveforms you have transferred to the source by first selecting the waveform from the combo list then click on the "Delete selected wave" button. After the waveform is deleted, sine wave will become the active waveform.
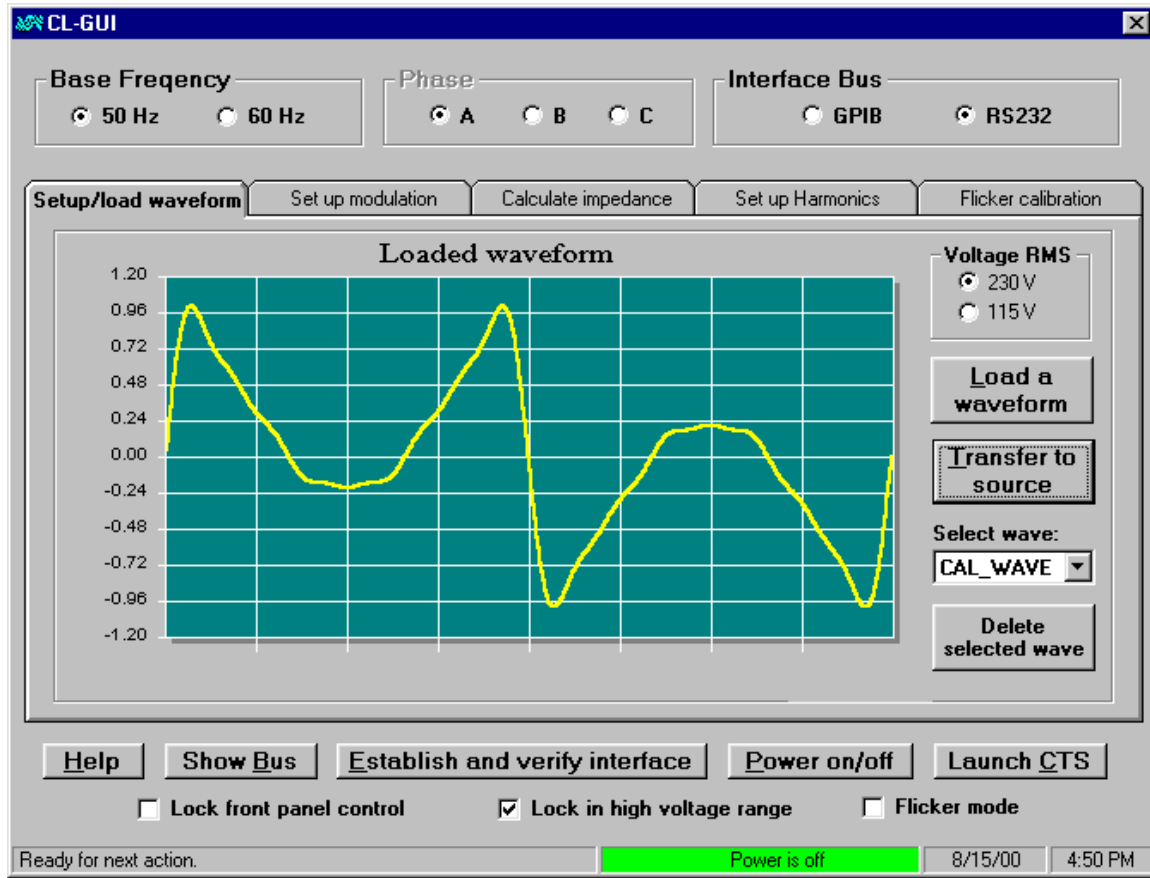
Figure 9-2: Loaded Waveform
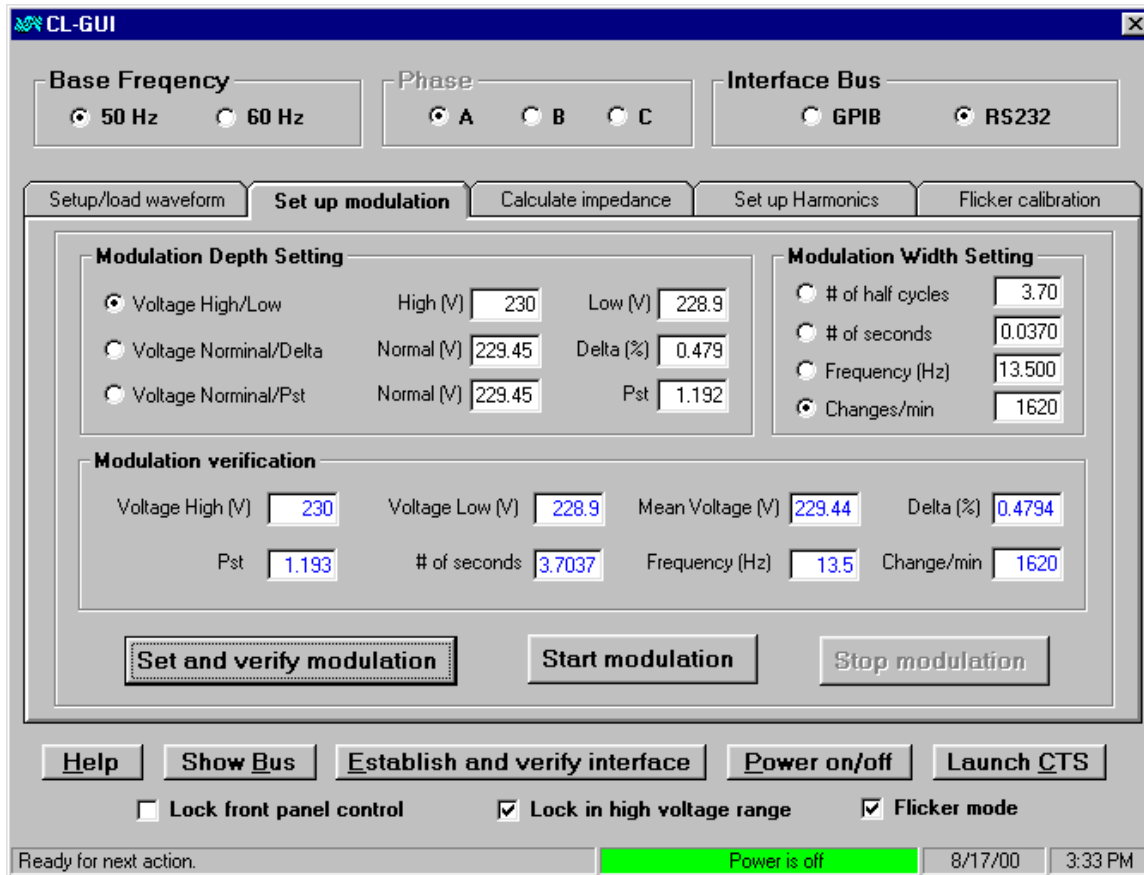
9.3 Set Up Source Voltage Modulation

Figure 9-3: Set Up Modulation Screen

Through this task, you can set up the power source to output a sine wave with rectangular modulation. By setting up the voltage modulation you can run CTS and check on the flicker calculations. To set up the modulation, you need to set up both the modulation width (frequency) and depth (voltage variation).

To set up modulation width, choose an option from the four in the "Modulation Width Setting", then enter the value in the field next to the choice. As you will notice, once you press "Enter" key after entering a value, the three other fields will also be filled with appropriate values.

To set up modulation depth, choose an option from the three in the "Modulation Depth Setting", then fill in the fields next to the choice. Similar to the modulation width, as soon as you press "Enter" key after you fill out the fields, the other four fields will also be field with calculated answers.

Once the modulation width and depth are set up, click on the "Set and verify modulation" button to set the power source to the desired modulation. However, the modulated voltage output does not begin until you press the "start modulation" button.
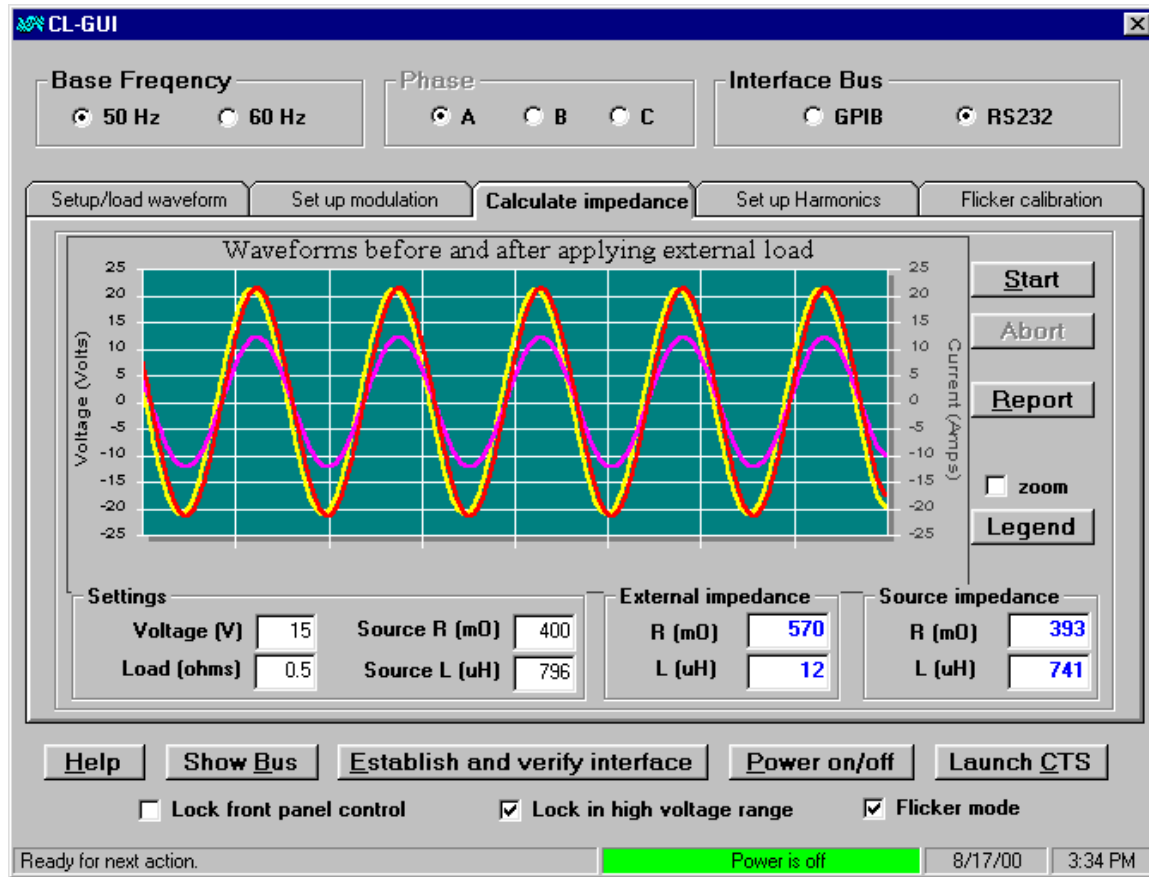
9.4 Determine the Power Source Impedance

Figure 9-4: Impedance Calculation Screen

This task is to perform an impedance calculation/calibration/verification of load and source. To achieve the desired accuracy for the internal (source) impedance, it should be performed with an external load of about 0.5 Ohms. With this kind of load, the voltage output is necessarily small, normally about 10 volts. The source R and source L should be set to 400 mOhms and 796 uH to be consistent with the EN60003-3 standard.

Calculating the impedances involves acquire a voltage waveform without load, and a pair of voltage/current waveforms with a load. Once you click on the start button, the program will lead you through the procedures step by step. Please be sure to follow the instruction. In addition, this acquisition cycle may be repeated several times (see discussions on the 2300CL.defaults) to improve the accuracy. After each acquisition cycle, the three waveforms will be show on the screen, but the impedance values will not be reported until all required cycles are complete.

If you have a three phase power source, you may need to perform impedance calculation on all three phases. This means you need to repeat the work one phase by one phase.

Once you complete an impedance calculation, you can generate/print a report on the calculation by clicking on the "report" button. Figure 9-5 is a sample of the report.

```
          Calibrator Impedance Calibration Report

Calibrator serial #: A10234
Power source info: "CALIFORNIA INSTRUMENTS,5001IX-400,53418,Rev 2.06"
Calibrated by: Calibrated by
Calibration Date: 7/28/00
Calibration Time: 3:46:14 PM

Calibration frequency (Hz): 50
Calibration voltage (Volt): 15 (High range)

Phase: A

External load (Ohms): 0.5
Programmed resistance R (mO): 400
Programmed inductance L (uH): 796

Measured external resistance (mO): 548
Measured external inductance (uH): 23
Measured internal resistance (mO): 406
Measured internal inductance (uH): 765

Measurement data:
  Voltage RMS -- no load condition (Volt): 14.990
  Voltage RMS -- with load condition (Volt): 8.330
  Current RMS -- with load condition (Amps): 15.212
  Phase angle between voltages (degrees): 13.79
  Phase angle between voltage and current under load (degrees): 0.75
```

Figure 9-5: Calibrator Impedance Calibration Report

9.5 Set Up Power Source to Specific Harmonics
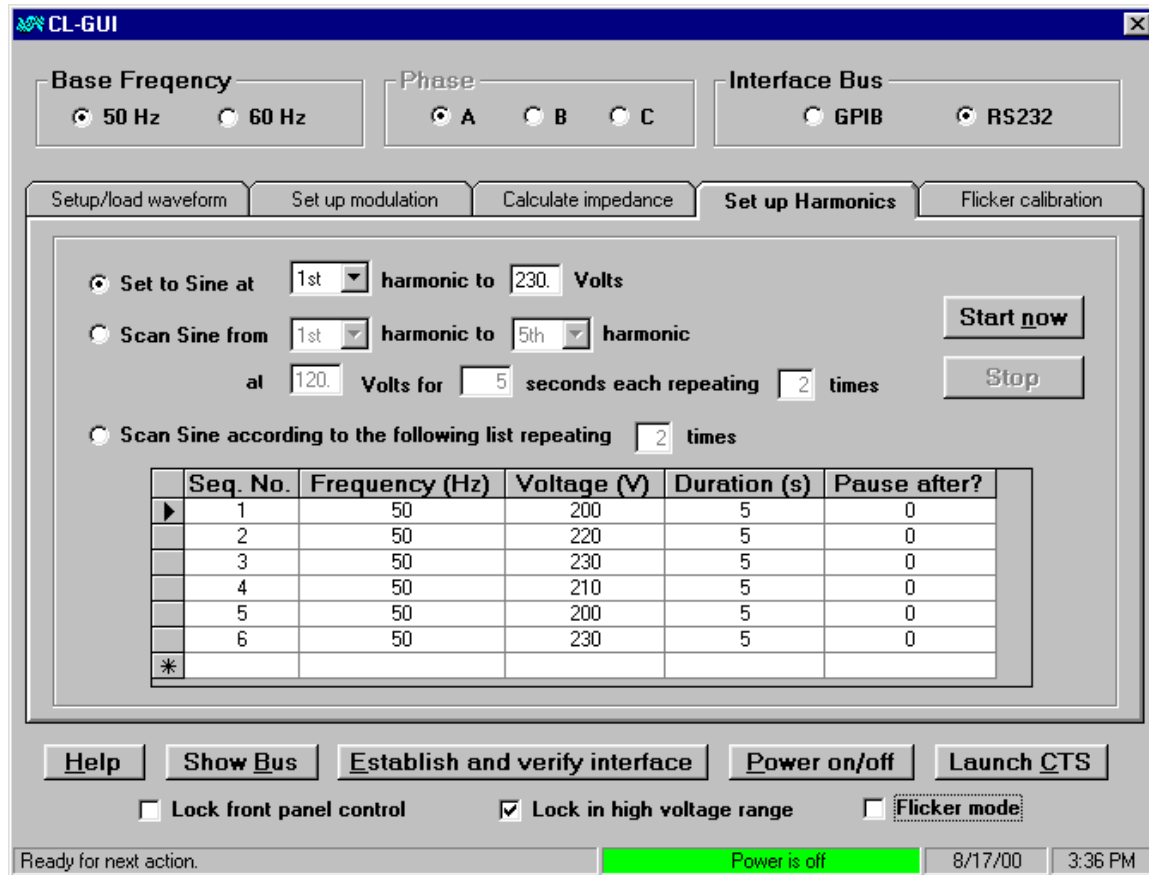
Figure 9-6: Set Up Harmonics Screen

This task enables the user to set up the power source at specific harmonics with specific voltage level. It is for sine wave only. It can also scan multiple harmonics/frequency at specified time interval and repeating specified times and even allows pausing after certain scan. To begin a scan, turn on the power and click the "start now" button.

Please note that any frequency scan above 500 Hz is achieved through the use of SINE_5F function. This function is an arbitrary waveform that happens to be a sine of 5 times the programmed frequency. For example, to achieve 20th harmonic with 50 Hz waveform, the program select SINE_5F, set the frequency to 200 Hz (200X5=20X50). For frequency less than 500 Hz, the program sets the frequency directly and uses SINE function.

When the source is set to above 500 Hz (true frequency), the voltage limit will be physically limited due to thermal dissipation. As a result, the power source may reach its thermal limit. For this reason, the program checks for the over temperature at a specific interval (see discussions on the 2300CL). When a over temperature is detected, the program will turn off the power automatically.

9.6 Documenting the Flicker Calibration

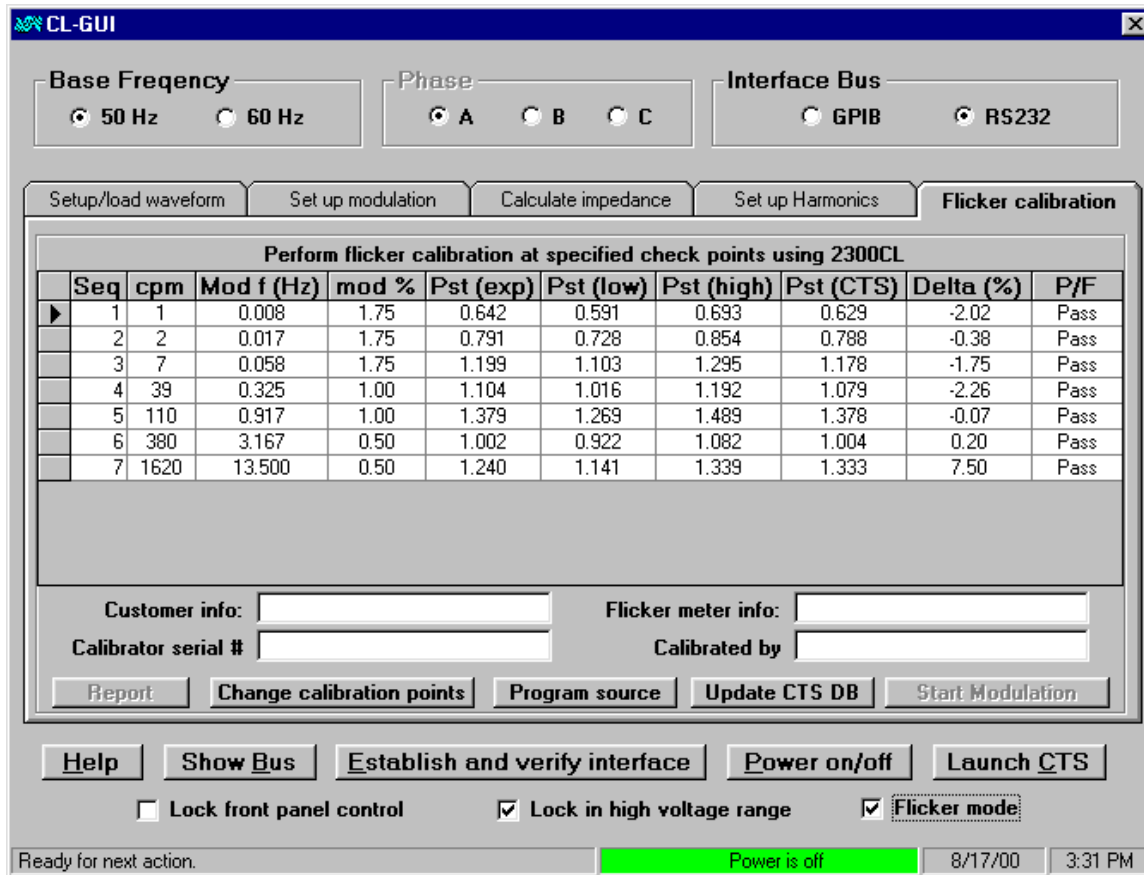*Figure 9-7: Flicker Calibration Screen*

This task is to be associated with operation of 2300CL flicker calibrator. It also controls the power source voltage and impedance. Normally, a table containing a list of pre-selected calibration points is shown as in Figure 9-7. In this table, the only column that can be modified is the column with P_{st} (CTS). The operator must set the 2300CL calibrator to specified modulation depth and set the iX to specified impedance values. Then a flicker meter such as that of CTS 2.0 can be used to obtain the P_{st} value then manually enter the value in the table. Once the value of a calibration point is entered and the record cursor is moved to a different record, the program will determine the Delta (% deviation from the expected value) and P/F (pass/fail). Please note that in order for the entered value to be saved into a database and used for calculation of Delta, the cursor must be moved to another record.

To get the right voltage modulation depth ($\Delta V/V$), it is critical that the source impedance be correctly set. The standard calls for 0.4 Ohm resistive and 796 uH inductive impedance. The effect of inductive part to the voltage is very small in general. However, The P_{st} and P_{lt} are very sensitive to the resistive part and consideration must be given to the resistance present in the wires/cables. For example, if the resistance due to cabling is 0.025 Ohm, the 1.75% modulation setting on 2300CL with programmed 0.4 Ohms can produce 1.87% modulation. This will leads to P_{st} and P_{lt} that are 6.9% larger than the true values. To accommodate the additional resistance in the wiring, it is suggested that the following steps be taken in order to set the IX impedance:

1. Click on "Program source" button and set iX power source impedance to R=0.4 Ohms, L=796 uH;
2. Set the 2300CL modulation depth to 1.75% and press in the DC button;
3. Run CTS (or flicker meter) and wait until waveforms are shown;
4. Push and hold "DC TEST" button on 2300CL;
5. Record the d_c value shown on CTS or flicker meter;
6. Compute $\delta=(d_c/1.75-1)*0.4$;
7. Set iX to R=0.4-δ Ohms and L=796uH;
8. Repeat Steps 3 and 4. This time, you should have d_c=1.75%; and
9. If you use CTS as your flicker meter, you should click on "Update CTS DB" button to update the database for CTS system. Please note that when CL-GUI is running, CTS program will not control the power source. The new R value will not be used by the CTS. However, when you launch CTS after you exited CL-GUI program, CTS will have the source control and it will program the source according to your saved R and L values.

For CTS with OMNI, follow the steps below:

1. Click on "Program source" button and set iX power source to be R=0 and L=0. This will put the iX in the minimum impedance state.
2. Set the 2300CL modulation depth to 1.75% and press in DC button
3. Run CTS and wait until the waveform are shown;
4. Push and hold test DC button on 2300CL
5. Record the d_c value shown (You may want to do the last step several times to get an averaged value)
6. If CTS is running, closed it.
7. Click on "Update CTS DB" button and you will be prompt to enter the recorded value.

When you run CTS flicker the next time, the instant P_{st}, P_{st}, and P_{lt} are all corrected for the impedance deviation. Other parameters such as d_c, d_t, d_{max}, however, will not be affected.

To generate a report, click on the report button. A text file will be generated. Figure 9-9 is a sample of the report.
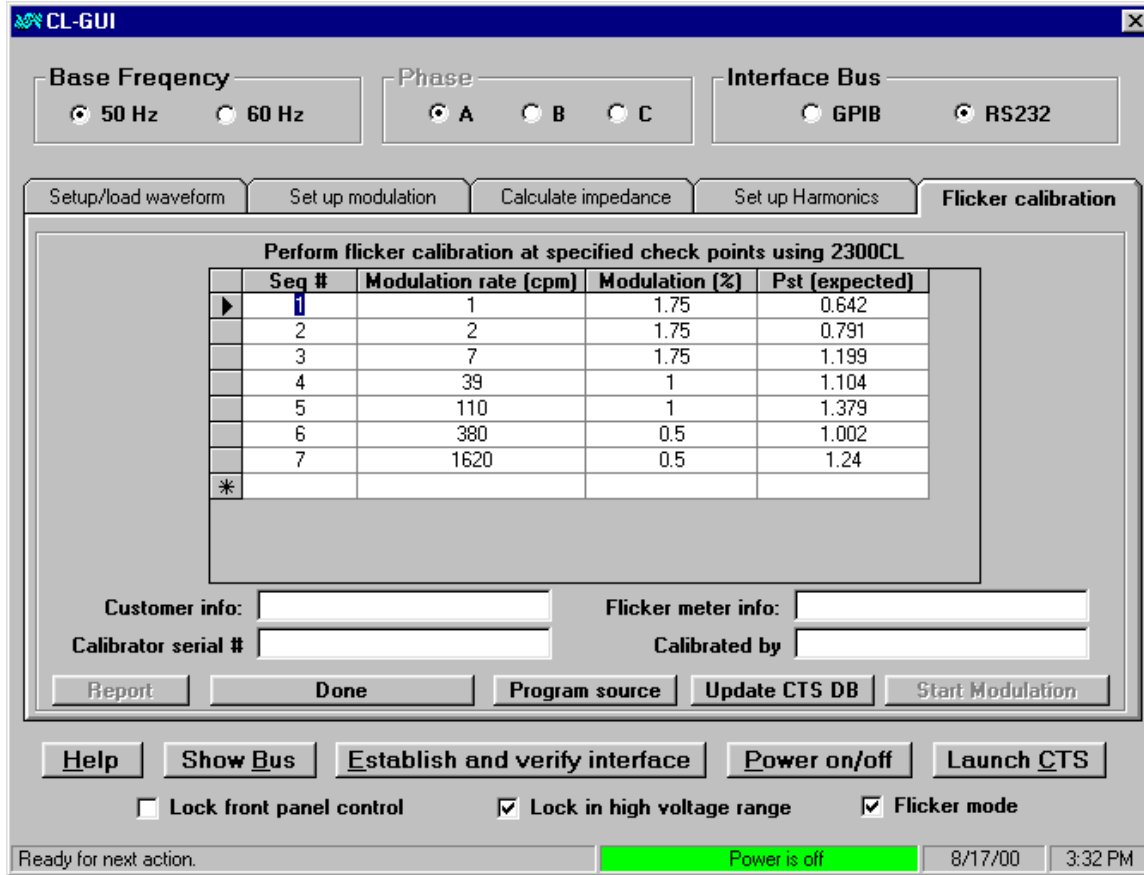
Figure 9-8: Change Flicker Calibration Points

To generate a report, click on the report button. A text file will be generated. Figure 9-9 is a sample of the report.

```
                    Flicker Meter Calibration Report

Customer info: Customer
Flicker meter info: CTS 2.0
Calibrator serial #: First unit
Power source info: "CALIFORNIA INSTRUMENTS,5001IX-400,98765,Rev 2.10"
Calibrated by: YL
Calibration Date: 8/17/00
Calibration Time: 3:47:16 PM

Calibration frequency (Hz): 50
Calibration voltage (Volt): 230
Calibration Impedance-R (mOhms): 400
Calibration Impedance-L (uHenry): 796

Seq  Mod rate  Mod freq  Mod depth   Pst     Low    High    Pst     Delta   Pass/
(#)    (cpm)     (Hz)       (%)      (est)    Pst    Pst    (CTS)     (%)    Fail
--------------------------------------------------------------------------------
 1        1      0.008      1.75     0.642   0.591  0.693   0.629   -2.02    Pass
 2        2      0.017      1.75     0.791   0.728  0.854   0.788   -0.38    Pass
 3        7      0.058      1.75     1.199   1.103  1.295   1.178   -1.75    Pass
 4       39      0.325      1.00     1.104   1.016  1.192   1.079   -2.26    Pass
 5      110      0.917      1.00     1.379   1.269  1.489   1.378   -0.07    Pass
 6      380      3.167      0.50     1.002   0.922  1.082   1.004    0.20    Pass
 7     1620     13.500      0.50     1.240   1.141  1.339   1.333    7.50    Pass
--------------------------------------------------------------------------------


Signature _____  Date _____  Location _____
```

Figure 9-9: Flicker Meter Calibration Report

9.7 Program Configuration Options

The CL-GUI has a few parameters that a user can modify to customize the need. These parameters are listed below with explanations after.

timer interval (ms) = 1500

response delay (ms) = 25

Impedance loop number = 5

Impedance current tolerance (mA) = 0.005

Initial delay after turning on load (ms) = 3000

Delay between two current readings (ms) = 1500

Allow calibration points change = 0

External OMNI existing = 0

CTS/WIN2100 directory =C:\program files\california instruments\cts

9.7.1   Timer Interval (ms)

CL-GUI has an internal clock that checks for the output state and overload status. This check is done every specified interval after the power control is established. This check is disabled, however, when the program is doing a waveform transfer or in the middle of impedance calculation process (Task 3). To disable this check, set the value to 0.

9.7.2   Response Delay (ms)

This delay should be 20 or larger. This value is the wait delay between after each query command is issued to the power source and reading of the response. For some system, it may be necessary to increase this value.

9.7.3   Impedance Loop Number

This number is used for Task 3 during the impedance calculation. To achieve the desired accuracy, the impedance measurement cycle may need to be repeated several times. This number specifies the number of measurement cycles.

9.7.4   Impedance Current Tolerance, Initial Delay After Turning On, and Delay Between Readings

During a impedance measurement cycle, a current waveform needs to be acquired. It is crucial that a stable state is reached before the waveform is acquired. During the time while the external load is applied, the program queries the current reading and check if the current has reached the stable state. "Impedance current tolerance" is the maximum deviation that is permitted between two consecutive current readings before deeming the current has reached the stable state. The time gap between the two consecutive reading is specified in the field of "Delay between two current readings". In addition, the program always waits for the amount of time specified in "Initial delay after turning on load" after the external load is applied.

9.7.5   Allow Calibration Points Change

The calibration points presented in Task 5 table are recommended points of flicker calibration. These points can be modified by setting this field to non-zero value. When "Allow calibration points change" is set to non-zero, "Change calibration point" button will be available for this task. Click on it will lead you to another table (see Fig 7) where you can enter the information of other calibration points you are interested. You will likely need to go to "Set up modulation". Tab to calculate the P_{st} (expected). Please be sure that after you enter the values in a particular record (line), move the record cursor to a separate record before clicking on the "Done" button.

9.7.6   External OMNI Existing

When set to non zero, CL-GUI will control iX but the impedance on iX will be set to minimum. The impedance network in OMNI can be engaged/disengaged through iX controller by checking on the "Flicker mode" check box.

9.7.7   CTS/WIN2100 Directory

If this line exists, the CL-GUI will launch CTS from this directory, otherwise it will launch from the default CTS installation directory.

9.8 P_{st} Calibration Check Procedure Using CL GUI

A Flicker test period of at least 10 minutes can be defined via the CTS screen. It is not necessary to complete the full 10-minute test to perform quick calibration verification. Select the Calibrator Function to P_{st} and set the modulation frequency to 3.17 Hz, and the modulation level to 0.50%.

Next, select the Function labeled Man/Ext. This stops the internal modulation and thus the voltage and current readings should be constant (provided the user does not have an external modulation signal connected to the Calibrator).

Start a new Flicker test via the CTS software. As soon as the CTS display shows the voltage fluctuation curve (about 15 seconds or so after starting a test) select the P_{st} function setting, and re-adjust the modulation frequency to 3.17 Hz if necessary. The CTS software display will indicate the actual Flicker parameters, and the instantaneous P_{st} value should rapidly converge to a P_{st} level of 1.00 +/- 5%. After 10 minutes, the system will calculate the actual P_{sti} value, but it will typically approximates the final value within two minutes after starting. Note that the level of 0.500% @ 3.17 Hz (380 changes per minute) is one of the points listed in Table -1 of EN60868 found on page .

If the readings are not within tolerance, either the system (Reference Impedance) is not configured or calibrated properly, or the system supply source (amplifier) does not perform within its specified limits. To check the supply source, terminate the Flicker test but leave the EUT power on. Make sure the PACS front panel indicates that the Ref. Impedance goes to the "by-pass" mode. In this condition, the system Reference Impedance is by-passed. Therefore, the calibrator DVM will now read the source voltage directly. The source output voltage should show very little change, irrespective of the load condition. To vary the load, select the d_c function, and select a modulation level of 1%. This will result in a current of about 5.7 Amp rms, and the Calibrator DVM will display the source output voltage under no-load and 5.7 Amp conditions. Since the 2000RP and "iX" power sources have very low output impedance, their output voltage will change very little irrespective of the load condition.

By setting the calibrator to the various load levels, the source voltage stability can be checked. Note that some of the smaller CTS systems cannot be loaded to the 2.00% setting. Record the

source voltage in no-load condition To do so, make sure the function test switch is set to the "dc" position. Now set the level switch positions successively to 013 - 0.25 - 0.50 - 1.00 leaving each position active for 30 seconds. Observe the current and voltage levels via the digital meters. The difference in voltage output level should be less than 0.2V rms irrespective of the load change. For systems capable of higher currents, the same process may be repeated at the 11.5 Arms level. The same process can be repeated after the Flicker test has started, i.e. with the Ref. Impedance in the circuit. Now, the voltage levels will vary, and the voltage drop is of course proportional to the current level and the Reference Impedance values. With a purely resistive load, - such as is the case with the Calibrator - the voltage drop should be equal to the current level times 0.4 Ohms. In other words, at a current level of 5.75 Amp, the voltage drop should be 5.75 x 0.4 = 2.3V rms or 1% (+/- 0.12V rms).

The IEC standard permits the P_{st} level at the source to be as much as 0.4. For the above test at the P_{st} = 1.00 level (3.17 Hz - 0.50% modulation), this would equate to 0.4/1.0 x 0.50 x 2.3 = 0.46V rms. Thus, the source voltage drop with the Ref. Impedance in "by-pass" mode should be considerably less than 0.44V rms. If the voltage drop is higher, either the wiring impedance or the source impedance is too high, and need to be adjusted.

Assuming the Flicker test at 3.17 Hz and 0.50% modulation completes properly, other modulation frequencies can be set as desired. Table - 1 shows all the modulation frequencies given in the standard for a P_{st} = 1 level. For example 475 CPM equals 3.96 Hz. At this frequency, a modulation level of 0.475% would result in a P_{st} level of 1.00. The calibrator permits a setting of 0.50%, which therefore should result in a P_{st} of 0.50 / 0.475 = 1.05 (+/- 5%). All other points can be similarly interpolated. Note that small modulation levels, i.e. those that would result in P_{st} readings < 0.5, may not always come within +/- 5%. The reason for this is that noise levels from the amplifier (source voltage), and overall system noise will contribute to the P_{st} level, and typically cause the error percentages to increase, as readings are lower. That is why the IEC standard permits P_{st} levels < 0.4 to be ignored. Also, for very low modulation rates, such as 0.008 Hz there are only few transitions, hence it is important to run the test for the full 10 minutes.

The IEC standard also has a second table with calibration verification checkpoints. This Table 9-2 is an abbreviated version of Table 9-1, and only has 5 checkpoints. These checkpoints are also shown on 39. The table shows the modulation frequency, and the modulation levels which are needed for a P_{st} = 1.00. The two rightmost columns show the available modulation levels of the Flicker Calibrator, and the P_{st} that will result when using these levels.

The checkpoint for 1 CPM utilizes either a level of 2.00% for bigger test systems, or 1.00% for lower power systems as the 2.00% may requires more current.

Changes per Minute (CPM)	Modulation Frequency (Hz)	% Modulation for $P_{St} = 1.00$
0.1	0.0008	7.391
0.2	0.0017	4.584
0.3	0.0025	3.842
0.4	0.0033	3.540
0.5	0.0042	3.350
0.6	0.0050	3.169
0.76	0.0063	2.979
0.84	0.0070	2.867
0.95	0.0079	2.765
1.06	0.0088	2.679
1.20	0.0100	2.579
1.36	0.0113	2.484
1.55	0.0129	2.349
1.78	0.0148	2.294
2.05	0.0171	2.193
2.39	0.0199	2.091
2.79	0.0233	1.989
3.29	0.0274	1.893
3.92	0.0327	1.789
4.71	0.0393	1.679
5.72	0.0477	1.571
7.04	0.0587	1.456
8.79	0.0733	1.348
11.16	0.0930	1.244
14.44	0.1203	1.150
19.10	0.1592	1.062
26.60	0.2217	0.975
32.00	0.2667	0.942
39.00	0.3250	0.906
48.70	0.4058	0.866
61.80	0.5150	0.842
80.50	0.6708	0.782
110.00	0.9167	0.725
175.00	1.46	0.635
275.00	2.29	0.551
380.00	3.17	0.500
475.00	3.96	0.476
580.00	4.83	0.423
690.00	5.75	0.367
795.00	6.63	0.321
1052	8.77	0.276
1180	9.83	0.283
1400	11.67	0.331
1620	13.50	0.402
1800	15.00	0.480

Table 9-1: EN60868 Flicker Table

CPM	Hz	% mod for $P_{st}=1$	Use setting	Desired result
1	0.008 Hz	2.	1.00 or 2.00%	0.367 or 0.734 **
2	0.017 Hz	2.211	1.00%	0.452
7	0.058 Hz	1.459	1.00%	0.685
39	0.325 Hz	0.905	1.00%	1.105
110	0.917 Hz	0.725	1.00%	1.379
1620	13.50 Hz	0.402	0.50%	1.244

Table 9-2: Flicker Meter Performance Check Points

10 Flicker Standards Tutorial

Flicker is caused by voltage fluctuations. The European Community (EC) requires that electrical products sold within the community meet certain standards. One of the requirements concerns flicker. Others include specific safety requirements, harmonics, EMI, RFI, ESD, etc. The US and other countries either have or are in the process of adopting their own flicker standards. This tutorial mainly deals with the European requirements. Flicker is measured in a rather specific manner, as will briefly be described in this tutorial.

10.1 EN/IEC61000-3-3 - EN60868 and IEC61000-3-15

The IEC60868 standard, and the European counterpart (EN60868) describe the flickermeter, and measurement concepts. They do not set limits for voltage fluctuations. This is done in IEC555.3, which has been revised a number of times, and ultimately resulted in the current EN/IEC61000-3-3 standard. The international IEC standards do not constitute legally binding documents. The European Norms (EN) are legally binding however, and have the force of law within the EC. Generally, the EN version will be identical to the IEC standard, although differences could exist. Within the IEC, an update of the flickermeter standard is underway as IEC61000-3-15.

IEC61000-3-3 sets limits for voltage fluctuations caused by electrical apparatus with a current level up to 16A rms per phase, when measured in accordance with IEC60868 (or IEC61000-3-15). The unit with which the instantaneous Flicker level is indicated, is called "P" for Perceptibility. Flicker causes irritation, and may affect people in their work. The unit for the short term "irritability factor" is called P_{st}, and the long term measurement unit is called P_{lt}. Perceptibility depends on both the amplitude of the voltage fluctuation and on the repetition rate with which the fluctuations occur. The human eye/brain system has a specific sensitivity curve for light flicker. This curve, the irritability threshold, and the measurement methods to be used, will be discussed next.

10.2 Flicker Testing Requirements per IEC61000-3-3

The UIE/IEC Flickermeter, as originally defined in IEC868 (the precursor to IEC60868), measures voltage fluctuations and then processes the data in a rather specific way. The intent of IEC868 and its Amendment-I, was to come up with an evaluation method which closely resembles the human eye/brain vision system. Therefore a relatively large sample of humans (1200) was subjected to light flicker, in order to establish irritability thresholds.

To measure the sensitivity to light flicker, the voltage to a standard 230 V - 60 Watt incandescent light bulb was varied in a controlled fashion. Voltage could be varied at programmable repetition rates, and the percentage fluctuation could be varied as well. It turned out that people are most sensitive to light fluctuations that occur with a repetition rate of around 1050 changes per minute. A small voltage fluctuation of only 0.276% at a repetition rate of 1052 changes per minute, is just as irritating as a 3% fluctuation that is repeated only 0.8 times per minute. Above approximately 1800 changes per minute (30 Hz) humans no longer perceive light flicker.

Figure 4-2 illustrates this human sensitivity to light flicker, as defined in the standard. The curve represents a constant irritability factor (P_{st} = 1) for rectangular voltage fluctuations expressed in percent of nominal (230 Volts) line voltage. As can be seen, at about 22 voltage fluctuations per minute, a fluctuation level of 1% has the same irritability level as a fluctuation of only 0.28% when repeated 1052 times per minute. The initial experiments yielded this sensitivity curve, which later was approximated by a Laplace transfer function. The latter is now the standard method to define the flicker curve, although it deviates slightly from the original curve. In real situations, voltage fluctuations generally do not occur in a square wave modulated pattern, as used to determine to sensitivity curve. Because voltage fluctuations generally occur in a quasi-random

fashion, methods were developed to evaluate the fluctuations, and then statistically process them, in order to assess how irritable they would be in terms of light flicker.

In order to assess the fluctuations, the RMS voltage level of every half cycle has to be measured, and its value is then used in a statistical computation process. For a 50 Hz system, this means that 100 measurements and RMS calculations per second are required. Those measurements need to be filtered, weighted, and processed statistically. Since flicker tests can take in excess of 2 hours, there is a lot of data to process. Thus, the overall flickermeter is a rather complicated measurement instrument (see IEC60868).

This concept is shown in Figure 10-1. The top portion of the figure shows the instantaneous voltage waveform, while the bottom portion shows a line which represents the rms value for each halve cycle. The voltage is measured via a reference impedance circuit as shown in Figure 4-1 on page 10.
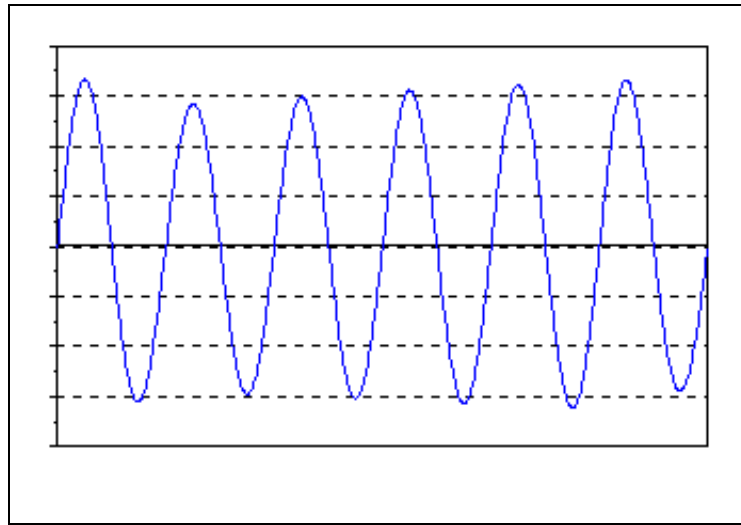

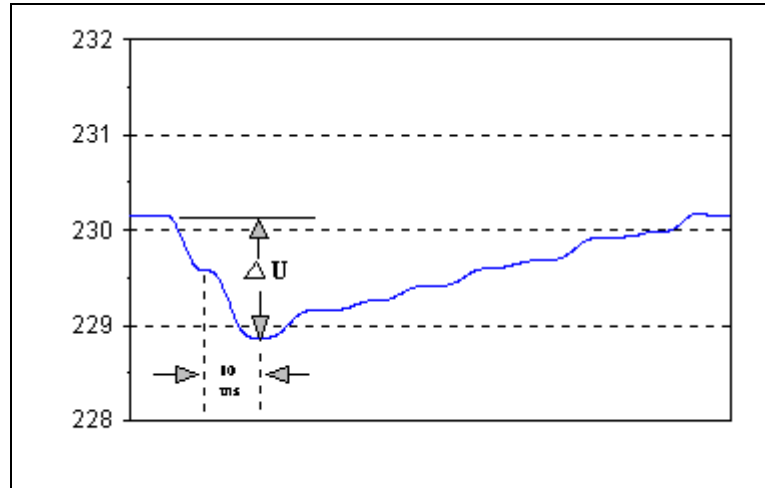*Figure 10-1: Voltage Waveform (top) and 10 ms Calculation (bottom)*

Figure 10-2: Relationship of d_{max} and d_c Parameters

The standard provides for several voltage characteristics to be evaluated. As explained before, the RMS value of each half cycle is measured. The successive measurement values are called Ut, for the instantaneous value of rms voltage (U). Thus, there is a new Ut value, after every 10 ms half cycle has been completed.

As the load is turned on (i.e. the EUT draws power) the inrush current causes a voltage drop across the reference impedance. The voltage drop decreases as the current level declines. The deviation of Ut can be expressed in percent of the nominal (230V rms) voltage value. This relative voltage change is then called d_t . The d_t values for each successive half cycle are used to calculate most other flicker parameters. In Figure 10-2, two successive half-cycle rms values each with a d_t of about 0.28% are shown. The total rms voltage level of the lowest measured half cycle is 228.85V rms, which is 0.56% less than the 230.15V rms nominal steady state level. The standard permits maximum changes of up to 3% between successive half cycles. In addition, the maximum relative voltage change, which is called d_{max}, shall not exceed 4%. d_{max} is a maximum **relative** voltage change, and that d_{max} is therefore updated for each voltage change period.

Some have misinterpreted d_{max} as the maximum voltage change during a complete flicker test. This is an erroneous interpretation, as the standard clearly describes this parameter as a **relative** voltage change. In the example of Figure 10-2, the d_{max} level would be - 0.56%, while the first d_t level (the level at the point where the first dotted line intersects with the voltage level line) is - 0.28% followed by another d_t of - 0.28% and then a small increase resulting in a d_t of + 0.12% etc.

The final parameter to consider is called d_c. This is the steady state voltage change. In other words, if a given UUT has two steady state conditions, with one causing the line voltage to remain 1% lower for at least 1 second, the resulting d_c value is also 1%. The existing version of the IEC standard limits the d_c parameter to a maximum change of 3%, while d_{max} is limited to 4%. An upcoming amendment will relax the limits somewhat, with d_c being permitted to reach up to 3.3%, and d_{max} values being permitted to reach 6 and even 7% for certain type products.
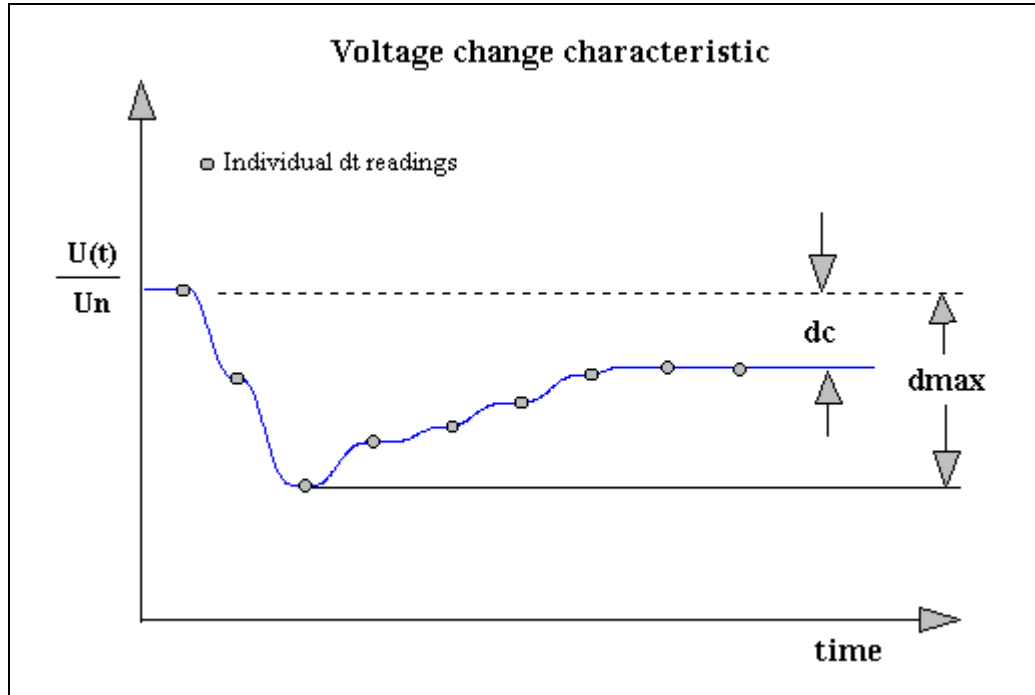
Figure 10-3: Voltage Change Characteristic

Figure 10-3 shows the relationship between d_c and d_{max} as referenced to the voltage change. As will follow from the foregoing, the voltage drop (flicker) is due to the current flow through the reference impedance (see Figure 4-1). Note that the reference impedance values include wiring as well as the power source impedance values. Since it is not always possible to exactly verify the source output impedance characteristics, an alternate method of source verification is permitted by the standard. In these cases, reference impedance with the shown values may be used, and the voltage is measured on the source output, as well as on the UUT terminals. If the voltage fluctuation at the source output is < 20% of the fluctuation measured at the UUT, the source is considered to have an acceptably low output impedance. Note however, that the source can still contribute nearly 20%, which leaves less margin for the UUT. So, it is in the interest of the UUT manufacturer to use a source with the lowest output impedance.

Other requirements that apply to the supply source are a total harmonic distortion < 3%, and the voltage level at the source output terminals shall be maintained within 2% for the duration of the test. If the measured P_{st} (short term flicker) is less than 0.4, supply voltage fluctuations can be ignored, however. Also, the supply voltage frequency shall be 50 Hz, +/- 0.5% (50 Hz, +/- 0.25 Hz) during the test.

As will be understood, the overall measurement accuracy of a flicker compliance test system depends not only on the power source and flickermeter. It is extremely important that the reference impedance has the correct impedance values. For example, if system wiring adds 20 milliohms of resistance, the resulting flicker readings will be in the order of 5% too high. The 2300CL Flicker Calibrator therefore is designed to allow the user to not only check the flicker meter, but also the source and reference impedance, i.e. verify the complete IEC compliance test system.

10.3 IEC61000-3-3 Flicker Calibration Record

System type/model: _____

CTS S/N: _____

Calibration date _____

Modulation Frequency	Level for $P_{st} = 1.00$	Calibrator setting	Target reading	Actual reading
1 (0.008 Hz)	2.724	1.00%	0.367	
2 (0.017 Hz)	2.211	1.00%	0.452	
7 (0.058 Hz)	1.459	1.00%	0.685	
39 (0.325 Hz)	0.905	1.00%	1.105	
110 (0.917 Hz)	0.725	1.00%	1.379	
1620 (13.50 Hz)	0.402	0.50%	1.244	

Additional test points

1052 (8.77 Hz)	0.276	0.25 %	0.906	
475 (3.96 Hz)	0.476	0.50 %	1.050	

Calibration performed by: _____

Signature:_____

Date:_____

Location:_____

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11 Index