Advanced Analyzers

User Manual

Model AA-HFA-3-36-REF

IEC 61000-3-11 Ed. 1 & 2	**IEC 61000-3-12 Ed. 1 & 2**

- **16 bit USB based data acquisition – works with Laptops & Desktop PC's**
- **Very accurate Windows-7, 8, 10 compatible power analyzer with data storage**
- **Control for most power sources incl. Ametek© Pacific Power© Teseq© etc.**
- **Optional ISO-17025 Accredited Calibration with detailed data available**
- **Optional built-in Reference Impedance per IEC 61000-3-3 and -3-11 available**

HARMONICS & FLICKER ANALYZER SYSTEM

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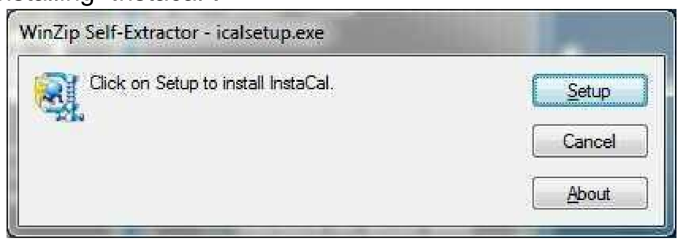
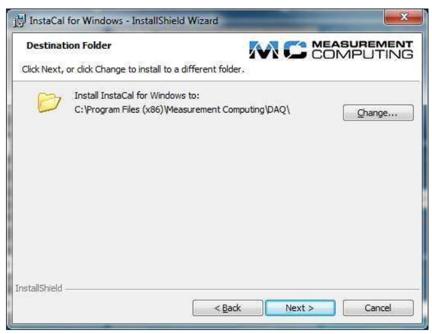
Software installation

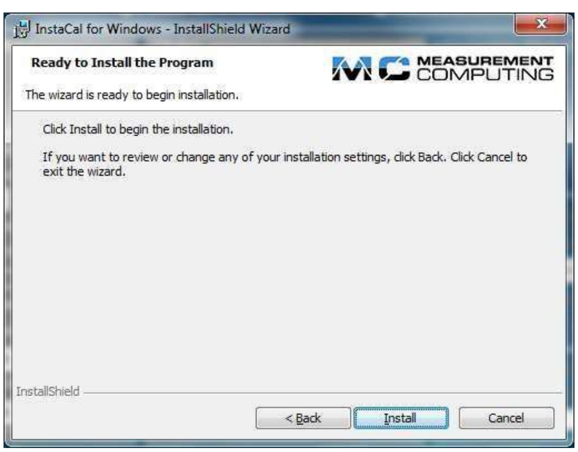
This section guides you through the software installation steps.

a. The HFa-3-75 utilizes a 16 bit A/D sub-system. A generic driver is required to facilitate communications between a PC, via a USB-2 or USB-3 port, and the card inside the HFA-3-75-3. The generic driver utility is called “Instacal”, and the driver executable is called “icalsetup.exe”. The executable file is located on the system CD. So, you insert the system CD into the drive of your PC, and locate the “icalsetup.exe” in the main directory of the CD.
b. After the Instacal executable loads, it may ask for permission the change system files (messages may differ slightly for Windows 7 or Windows 10). Click on OK or “Permit changes” and the software will continue the install process. Another window will pop up with WinZip self Extractor, and you click on OK to continue. Next, you click on “Setup” to proceed with installing “Instacal”.





A couple windows will pop up with a copyright notice, and an install directory. You click on “Next” several times to continue installation. Finally, the InstallShield program will show the next window that lets you start the actual driver installation.



You click on Install, and the installation process will create directories and copy the driver files. If it finds existing files, it maydelete these and install the newer driver files. This may take a couple minutes to complete. After you click on “Finish” the program may ask you to restart your PC, so that it can update all system files.

This process completes the Instacal installation. Next you need to install the VISA drivers that are needed to control the programmable power source (if you have a power source otherthan the public supply).

Figure 1 The USB card driver installation

Installing the VISA utility

This section guides you through the installation of the VISA utility.

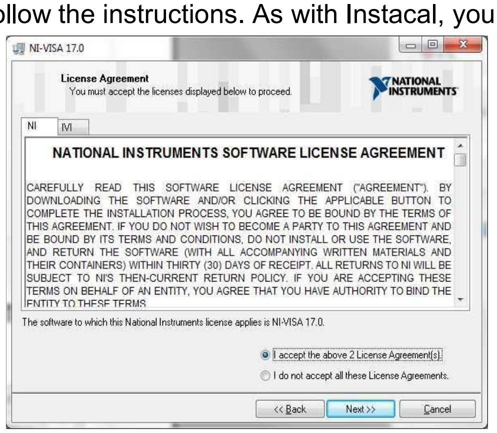
a. The Virtual Instrument Software Architecture (VISA) is a standard for configuring, programming, and troubleshooting instrumentation systems comprising GPIB, VXI, PXI, Serial, Ethernet, and/or USB interfaces. VISA provides the programming interface between the hardware and development environments such as the National Instruments LabVIEW, LabWindows/CVI, and ***Microsoft Visual Studio***. Visual Studio is used to develop the HFa-3-75 software. Many programmable power sources use the GPIB or Serial interface for control purposes, and thus the NI-VISA interface can be used to communicate with those power sources. The HFA-3-75 software can use the NI-USB/GPIB interface unit to communicate with power sources, or use the serial port that is still found on some PC's to control the power source. Also, a USB-RS232 (USB to COM) interface can be used. You can download the VISA utility from the NI web site, via the link below;

b. **http://search.ni.com/nisearch/app/main/p/bot/no/ap/tech/lang/en/pg/1/sn/catnav:du,n8:3.1637,ssnav:sup/**

c. ***For your convenience, a copy of the VISA install is included on the HFA-3-75 system CD. The program is called "NIVISA1750full.exe". Versions 17.0 and 17.5 were tested to work properly with the HFA-3-75 program, but later versions should be OK too.***

d. To install the VISA utility, you download the executable from the NI web site, or run it from the CD that comes with the HFa-3-75.

The process is very similar to the Instacal setup that is described in the previous section. You click on "Run" and just follow the instructions. As with Instacal, you may have to restart the PC after the installation completes.



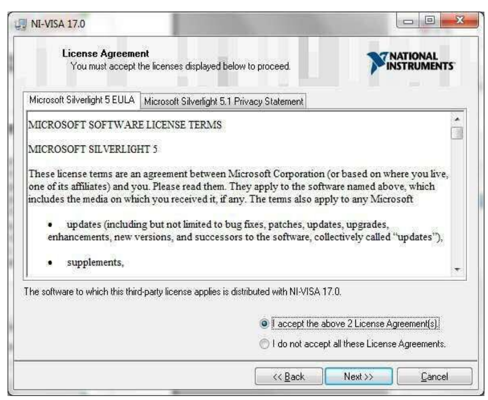


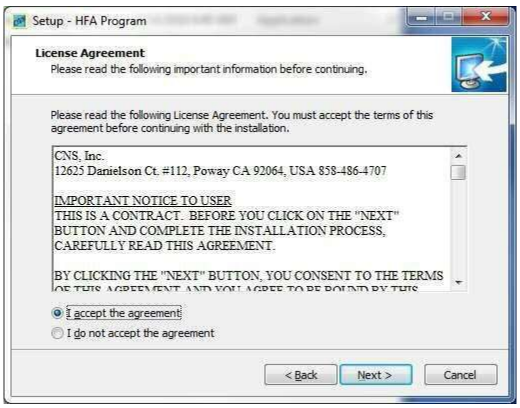
Figure 2 The VISA installation

Installing & Running the HFA-3-75 software

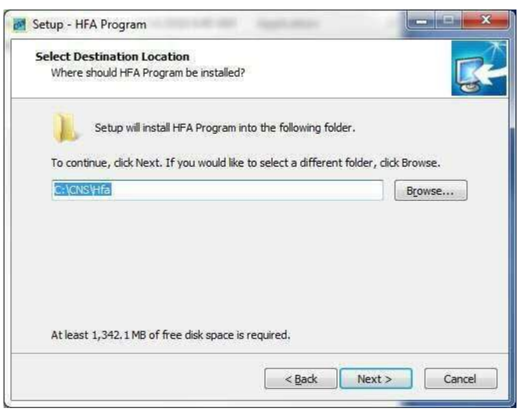
a. The software CD that comes with the HFa-3-75, includes an install executable, called;

HFa75.exe Program (may also have HFa16.exe for < 16A) Version 1.0.x.x.exe

b. where the "x.x" identify the software version number. Running the executable will result in a number of pop-up windows, similar to the Instacal and VISA utilities setup. Depending on your Windows version, you may have to allow the install program to make changes to your PC. You have to click "Yes to proceed with the installation, and then the Setup Wizard window will pop up.



You click on "Next" and the License Agreement window will pop-up, which you have to acknowledge, by clicking "Accept the agreement".



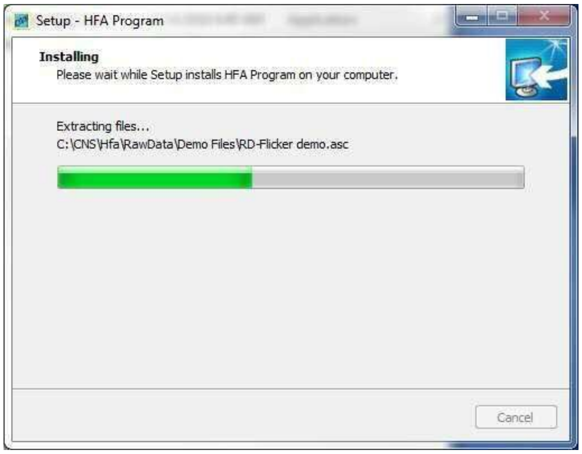
Then the install program will show the default installation directory, which we recommend you accept. Simply click on "Next". Also, the install program will ask you if it should install a desktop icon (shortcut), and after you click "Next" it will show a window listing the destination and start-up folders, as well as any additional tasks.

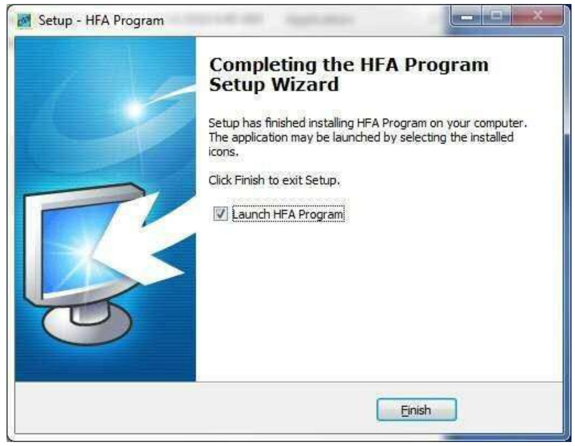
You then click on "Install", and the installation will proceed. The system will also install some demo files, which are actual test files for Class-A Pass and Fail. The HFA-3-75 stores the "raw data" files, much like a data logger does, so that the files can be replayed later.

Figure 3 The HFa-3-75 software installation

Additional demo files, including for Class-C < 25 Watt, and Flicker test files are available.

NOTE: Your install disk comes with a file called HFa75Calibration.xml. You MUST copy this file into the C:\CNS\HFa75 directory. It includes your specific license number. Without that number, the system will only run in demo/replay mode.





When the installation is complete, you click on "Finish" and this will launch the program.

Note, however that the installation process may copy a default calibration file to the hard disk. That "HFa-3-75Calibration.xml" file needs to be replaced by the file for your specific unit. Your calibration file has a license number embedded. If that license number is missing or incorrect, the system will allow replay of test data, but will not allow a real test.

In case you forget to copy the calibration file for your unit, the system will "complain" that the calibration file is for a different serial number, and ask you if you want to proceed. Below is the structure that the program will create on the hard disk (see page 8). The calibration file is located in the C:\CNS\HFa-3-75 directory. ***Without the correct software license number, the system will ONLY replay files.***

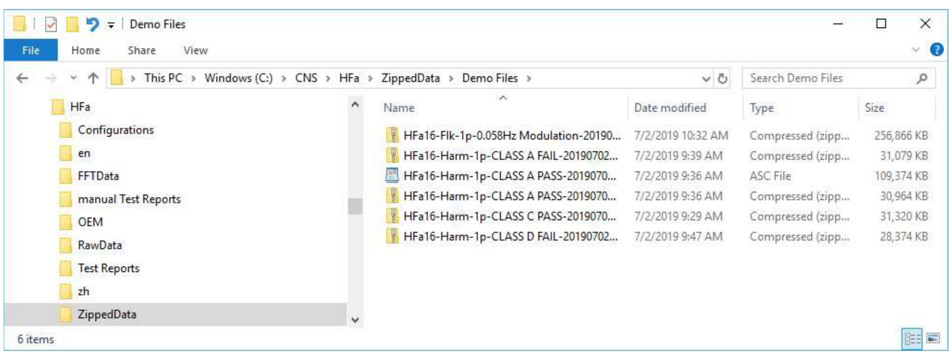


Figure 4 Software directory structure

The default calibration file will have the coefficients set to 1.000, and the system will be reasonably accurate, but not optimized for your specific serial number.

So, you should close the program, and first copyyour calibration file (over-write the default file). Then, re-open the program and it is ready to measure

Figure 5 Default Calibration coefficients.

Hardware connections

There are several versions of the HFa-3-36/75, see the pictures below

A: The 19” form factor AA-HFA-3-36-REF with built-in Reference Impedance for up to 36 A-rms

The AA-HFA-3-36-REF does all the signal conditioning. If the HFa-3-36/75 is used with a 30 kVA or 45 kVA powersource, the lines from the power source need to be connected to the back input power of the HFa-3. If an upgraded CCN1000-1/3 or PACS-1/3 is used with the HFa software, the PACS or CCN1000 needs to be connected to the power source as before. If the HFA-3-75 is connected to a PACS-1 or CCN1000-1, the system needs to be calibrated with the particular PACS or CCN1000.

B: The 19” HFA-3-75-Z-Ref-Ztest, for use with a 30-45-60 kVA power source – such as Pacific Power © AFX or Ametek© MX power sources. The HFA-3-75 is in a 19” rack unit, that includes the wiring between measurement and impedance units (see illustration on the next page).

C: The Teseq © and California Instruments © or Ametek © CCN1000-3 and PACS-3 upgraded to the (USB based) HFa-3-75. These units do not include the impedance for Flicker testing, i.e. require the external (1 or 3 phase) Z-Ref and Z-test units that came with the original system, or (for single phase) the programmable impedance in the power source can be used. .

Note; For direct connections (the normal operating mode) the calibration file that comes with the HFA-3-75 needs to be copied into the C:\CNS\HFa-3-75 directory. Alternatively, the user can run the calibration utility (see next pages).

Figure 6 *Part of the 19" rack, showing the HFa-3-75, and the Impedance units behind the louvered front panel.*

Figure 7 *Part of a California Instruments© MXCTSHL 19" rack, showing the PACS-3 upgraded to HFa-3-75 (top unit), and the 37 Amp Z-Ref below the HFa and the 75 A Z-test Impedance unit below the 37A and 75 A circuit breakers.*

Figure 8
A Teseq (Ametek CTS) Profline©
system with the CCN1000-3 (top unit) upgraded to HFa-3-75

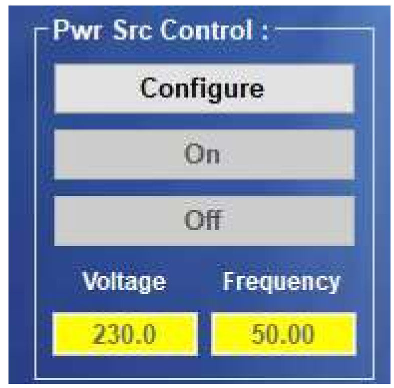
Figure 9 *Detail of the 19" form factor CCN1000-3 upgraded to HFA-3-75 (notice the USB plug above the DB-37 connector in the front)*

To operate the HFa-3-36/75

- The HFa-3-75 works for both the HFa-3-36 and HFa-3-75. The power level depends on the power source (or the rating of the public supply).
- Connect the "Power in" rear panel terminals to a suitable power source. The public supply 100 / 120 V or 220-230 Volt can be used for pre-compliance testing.
- Connect the equipment under test to the "Power to EUT" connector (front panel Plug-Sleeve for 3 phase or Schuko for single phase).
- Select a Test Condition Table-2, 3-, 4, or 5, and R_{sce}, the test time, and start the HFA-3-75 software.

Test voltage & frequency selections;

The system Setup will "pick up" the voltage and frequency settings from the Test Conditions screen. If the communication with the power source has been established, the user can turn-on/off the power with the buttons in the Pwr Src Control. The voltage and frequency settings in the yellow boxes will be transferred to the power source. The yellow fields are "read only" however. The power can be turned "on" to let the EUT start up.



*Note that you can **only** change the voltage and frequency in the Test Conditions screen. The yellow boxes are "read only".*

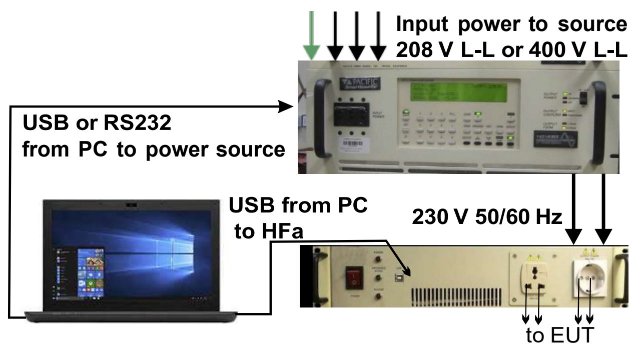
The software automatically changes the operating range (for example 150 V or 300 V) of the power source if the source has that capability.

Power source control

The power source can be controlled (depending on type) via RS-232 (most common) or via USB, or via GPIB.

Alternatively, the user can select Manual Control, and set the voltage via the source front panel.

Note that the user cannot have a source control program running – using the same port - that the HFa-3-75 also needs to control the power source.



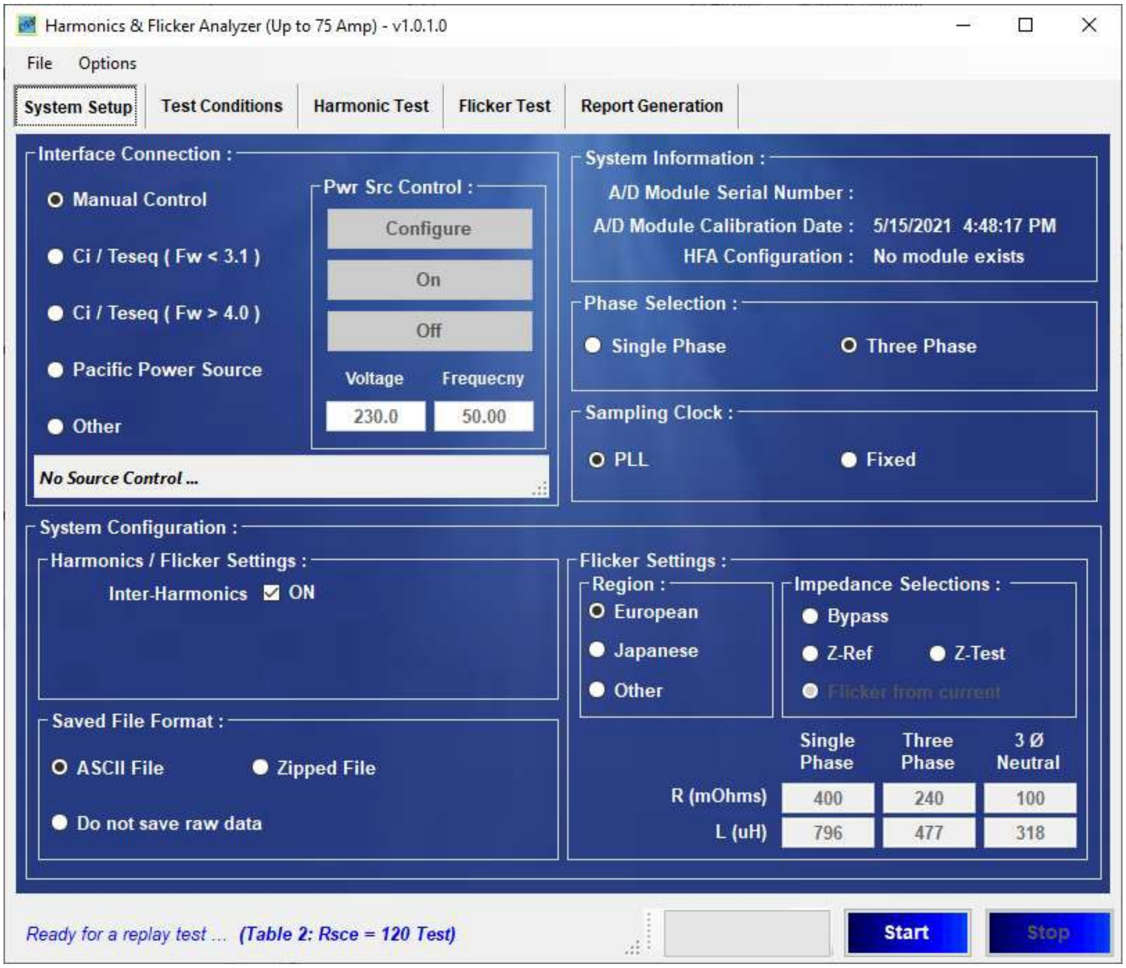
Many power sources have a "low" and a 'high" range, typically being 150 V and 300 Volt.

In the High range, a 45 kVA power source (MX45 or 3450AFX, or 3500AZX) is limited to about 63 A/phase @ 230 Volt, while it can double that current in the low range (say for 100 Volt or 120 Volt tests).

Most power sources require that the output is "off" when changing ranges. So, if the user changes the test conditionsfrom 120 V to 230 v or vice versa, the power source output must be turned "off" to change range. When the source isthen turned "on" either via the Pwr Src Control button, or by clicking Start in the test screen, the source will be programmed by the HFa-3-75 to the applicable range.

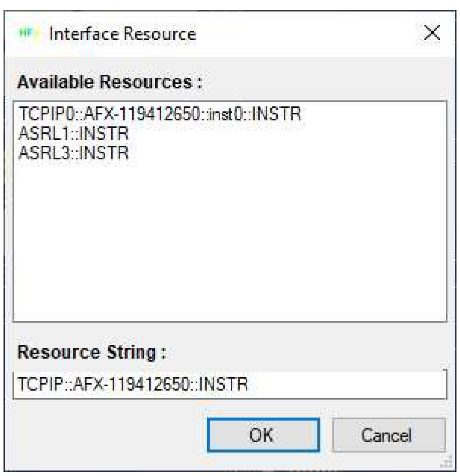
Note that the harmonics test standards IEC 61000-3-12 (and also 61000-3-2 <16 A/phase), allow the user to ignore the first 10 seconds after the EUT is turned "on". So, the HFa-3-75 will first do a 10 second pre-test, before starting to evaluate the harmonic current emissions per IEC 61000-3-12.

The system setup screen



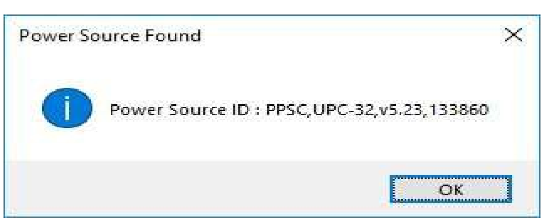
The setup screen lets the user select a powersource type and configure the communications interface. Configuring the communication witha power source is easily accomplished.

Figure 10 System Configuration screen



After you select a power source, and click the “Configure” button, you select which “port” from the “Available resources” the system PC uses for communications. When you click the “OK” button to verify connection – the HFA-3-75 verifies this by sending the “*IDN?” command. If communication is successful, it will indicate that the power source is found and the instrument ID string will be displayed. (This can also be viewed if you run the NI I/O trace)

Note that you can also opt for manual control, using the source front panel, or even use the public supply (100 – 120 - 220 or 230 V 50/60 Hz) as the test voltage. Using the public supply is normally a pre-compliance test, because the voltage distortion is often more than the standards permit.



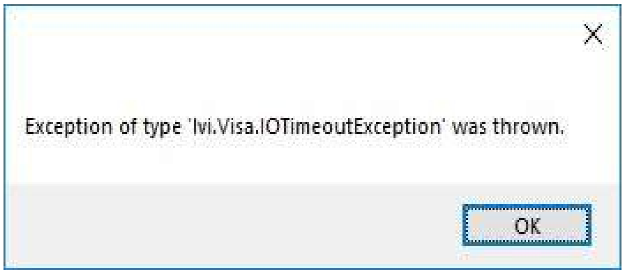


Figure 11 VISA exception error

If you get the “VISA exception thrown” message, the power source (MX45 in this case) is not responding to the *IDN” command. In some cases, like the AMX, you may have to push the “clear” button on the power source front panel, so that the communication port is made available to the PC. Of course, if there is no communication, you also need to check the interface & cable to the source.

Various power sources will go into “remote” (for example with GPIB / IEEE-488 control) ***and you may be locked out*** from using the front panel controls. We try to avoid this situation, but sometimes this is beyond the HFa-3-75 software control. If you are using Manual Control or the public supply (for example 230 V – 50 Hz, or 120 Volt – 60 Hz) or front panel control of the source, the system will not ask you to verify/configure the power source communication.

After you verify communication with the power source, a new test can be run. You can select the voltage and frequency, and the power source will be programmed accordingly. You can check via the front panel of the power source, to make sure the right voltage and frequency have been programmed. Also, for some power sources, the programmable impedance is set to the required values, being minimum impedance for harmonics, or the Reference Impedance values for Flicker.

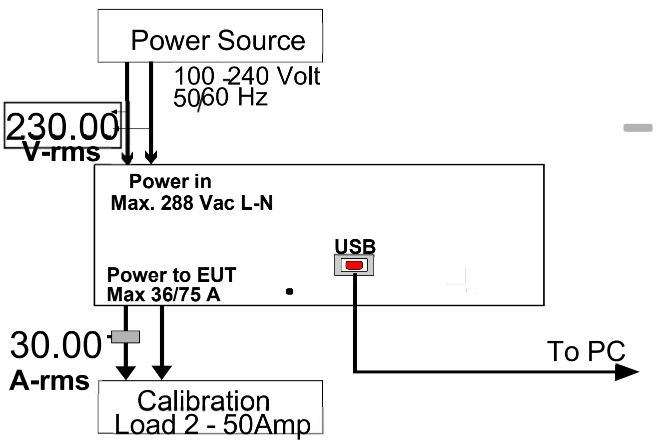


Figure 12 *Hardware connections* for *calibration*

When you have configured all the software, and “Start” aharmonics or Flicker test, the system will check the calibration data, and several other parameters.

If you see the error messages as shown in the next page, after you click “Start”, the system does not have the (correct)calibration file***. If you did not copy the right calibration file, with the correct license number, you can still replaydata files. To run real tests, you must first first copy the correct calibration file with license number to the C:\CNS\HFa-3-75 directory***.

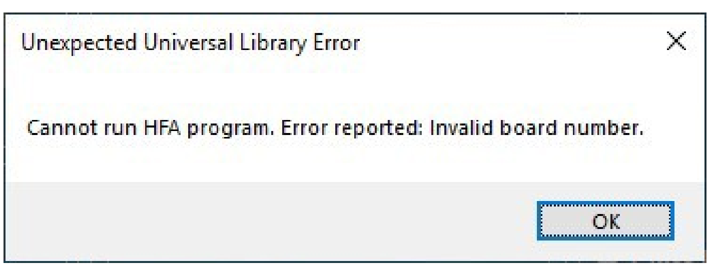


Figure 13 Incorrect or missing calibration file

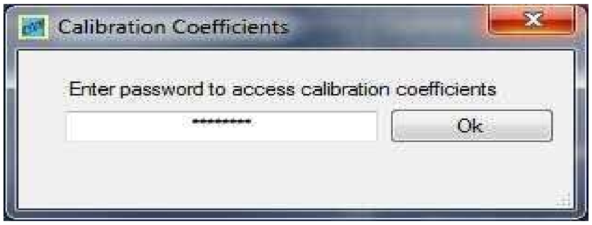
In the event that you do not have the calibration file, you can request it from ATEC. To verify calibration, you shouldfirst arrange for an external reference voltage and currentmeasurement method (see above figure 12 for the setup).

By applying a known external load, and measuring voltage and current with reference equipment, the user can update the cal-constants so that the HFa-3-75 indicates the exact same values as the reference voltage and current meters. This process is easy and takes no more than 5 minutes.

So, prior to performing the calibration, connect the HFa-3-75 to your power source, and connect a load that can be set to about 20-30 A-rms. Then proceed as follows (this assumes you have the correct calibration file to begin with).

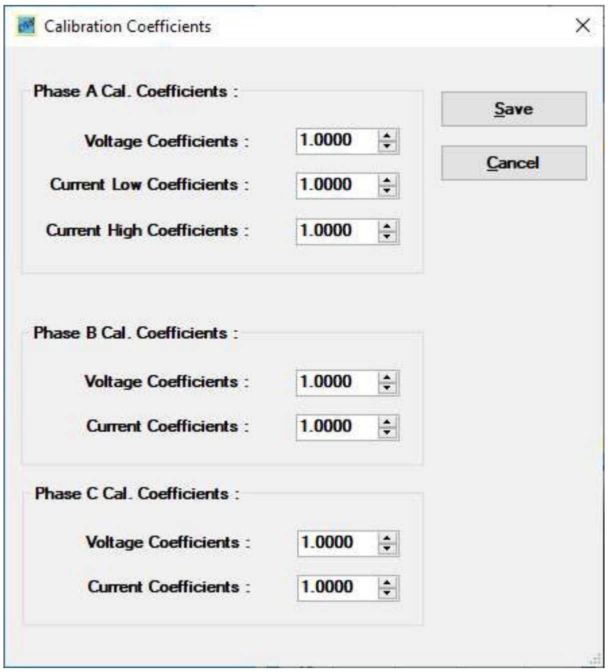
Step 1: Start a harmonics test for a duration of say 3 minutes (for a stable load).

Step 2: Activate the calibration parameter process, by double clicking on "A/D Module Calibration Date" in the System Setup, as shown. Then switch to the Harmonic Test display.



A small window will pop up that requires you to click OK to continue. This to make sure that you do not inadvertently change the calibration file.

The system calibration can be updated by entering the new cal. Constants. There are 2 current ranges for Phase-A to be calibrated. The 3 phase calibration screen is shown below.



Step 3: Do not apply a load as yet, i.e. the voltage is adjusted without a load. Set the power source to the desired test voltage, such as 230.00 V-rms. Adjust the voltage calibration coefficient so that the voltage reading in the Harmonic Test display of the HFa-3-75 matches the Reference DVM reading (± 0.1 V equal to 0.043%).

If the coefficient needs to be adjusted to a value that is less than 0.9700 or more than 1.030, the hardware calibration of the HFa-3-75 should be performed first – see later in this manual.

Step 4: Apply a load to each Phase that takes a current between 20.000 – 30.000 A-rms. The exact current level is not important, but it should be at least 20.0 Amp rms, and it should be stable. Adjust the "Current High Coefficients" so that the HFa-3-75 displaysthe same level as the external reference meter (± 10 mA i.e < ± 0.5 %). During the calibration process, observe the voltage reading of the reference DVM and the HFa-3-75. ***When you apply the high current, the voltage should NOT decrease more than 0.25 Voltfor every 10 Amp (i.e. be < 0.5 Volt for 20 Amp).*** If the voltage drops more than 0.25 Volt per 10 Amp, the ***power source impedance plus wiring*** to the HFa-3-75 is more than 25 mΩ, and this may result in flicker readings that are higher than they should be. If the voltage drop is acceptable, i.e. the power source and interconnect wiring are suitable, you can save the calibration data. If the voltage drop is too high, the system should be used with caution for Flicker compliance testing.

Step 5: Apply a load to Phase-A so that it takes a current between 1.500 – 2.500 A-rms. Make sure the load is stable. Adjust the "Current Low Coefficients" for Phase-A so that the HFa-3-75 displays the same current level as the external reference meter ± 3 mA (i.e. < 0.2 % deviation @ 1.500 A). Phase-B & C do not have a low current range.

Step 6: Click the Save button. This generates an updated calibration file, and you are now ready to perform accurate harmonics and flicker testing. You can copy the file called HFa75Calibration.xml and save it in case it is needed after a PC update of PC crash.

IEC 61000-3-12 harmonic emission limits < 75 Amp

The concept behind IEC 61000-3-12 for products up to 75 Amp (per phase) is a little different from IEC 61000-3-2. Whereas IEC 61000-3-2 permits an unconditional connection for products that meet the limits, IEC 61000-3-12 has variable limits – that in principle result in a conditional connection. For a connection at a point where the system impedance is lower, higher harmonic limits are permitted. Also, the standard has separate tables for single phase and 3 phase products, and two more tables that meet certain criteria, such as the phase angle of the 5th harmonic.

Table-2 Limits for single phase or non-balanced 3 phase equipment

Minimal R_{sce}	Admissible individual harmonic current I_h/I_{equ} [a] %						Admissible harmonic parameters %	
	I_3	I_5	I_7	I_9	I_{11}	I_{13}	THC/I_{equ}	$PWHC/I_{equ}$
33	21,6	10,7	7,2	3,8	3,1	2	23	23
66	24	13	8	5	4	3	26	26
120	27	15	10	6	5	4	30	30
250	35	20	13	9	8	6	40	40
≥ 350	41	24	15	12	10	8	47	47

The relative values of even harmonics up to order 12 shall not exceed 16/h %. Even harmonics above order 12 are taken into account in *THC* and *PWHC* in the same way as odd order harmonics.

Linear interpolation between successive R_{sce} values is permitted.

[a] I_{equ} = rated current; I_h = harmonic current component.

Figure 14 *Harmonic limits for single phase or other than balanced 3 phase products*

The Rsce stands for Short Circuit Current Ratio, which is the Short Circuit Power (Ssc) divided by the equipment power. So, as the Rsce increases (meaning the connection can deliver more power – or conversely – has a lower impedance), the limits increase. This can easily be understood. For example, a 5 amp 3rd harmonic that is present in a connection withan impedance of 0.4 Ω will cause a harmonic voltage of 5 x 0.4 = 2.0 V-rms. If, however, the connection has an impedance of 0.2 Ω, the resulting harmonic voltage is only 1.0 V-rms. The user tries to "PASS" the product test with a lower Rsce, and if the limits are exceeded, he/she selects a higher Rsce until the limits are met. The consequence, however, is that the equipment documentation has to call for the higher Ssc. So, the equipment manufacturer must;

- determine the minimum value of R_{sce} for which the limits given in Tables 2, 3,4, or 5, are not exceeded,
- declare the value of the short-circuit power S_{sc} corresponding to this minimum value of R_{sce} in the instruction manual,
- and instruct the user to determine, in consultation with the distribution network operator if necessary, that the equipment is connected only to a supply of that S_{sc} value or more.

Obviously, the lower Rsce, the lower the Ssc the manufacturer can declare, and the more connections will be suitable for the equipment. So, the connection is **conditional upon having a high enough Ssc.**

Whereas one simply selects the test class for harmonics per IEC 61000-3-2, one must first select which table to use, i.e. Table-2, Table-3, Table-4 or Table-5, and then select what Rsce level to use, which in turn determines the limits. The test setup is illustrated on the next page, where the user selects a Table-2 test, with an Rsce of 33.

For equipment that meets the limits with an Rsce of 33, the user can simply state;

"Equipment complying with IEC 61000-3-12".

For equipment that requires a higher Rsce, the above listed conditions / product information need to be provided.

IEC 61000-3-12 harmonic emission test setup

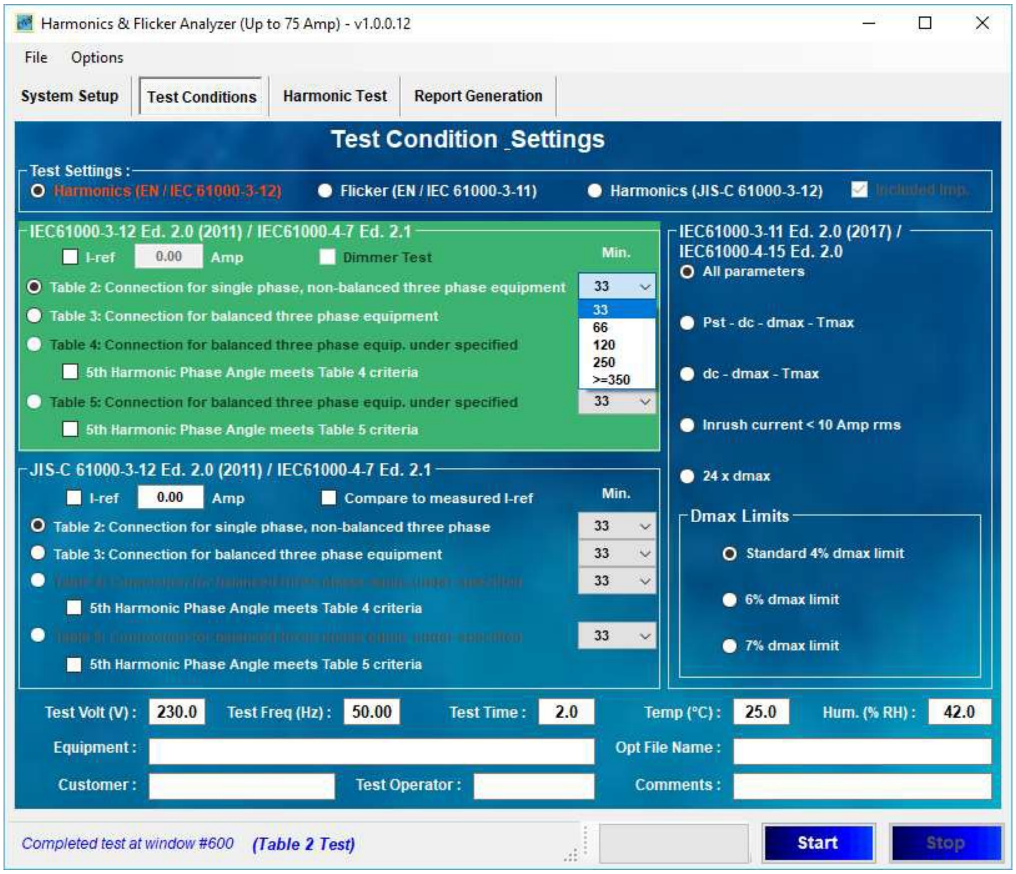


Figure 15 *Test setup for a Table-2 test with an Rsce of 33*

Minimal R_{sce}	Admissible individual harmonic current I_h/I_{equ} [a] %				Admissible harmonic parameters %	
	I_5	I_7	I_{11}	I_{13}	THC/I_{equ}	$PWHC/I_{equ}$
33	10,7	7,2	3,1	2	13	22
66	14	9	5	3	16	25
120	19	12	7	4	22	28
250	31	20	12	7	37	38
≥350	40	25	15	10	48	46

The relative values of even harmonics up to order 12 shall not exceed $16/h$ %. Even harmonics above order 12 are taken into account in THC and $PWHC$ in the same way as odd order harmonics.

Linear interpolation between successive R_{sce} values is permitted.

[a] I_{equ} = rated current; I_h = harmonic current component.

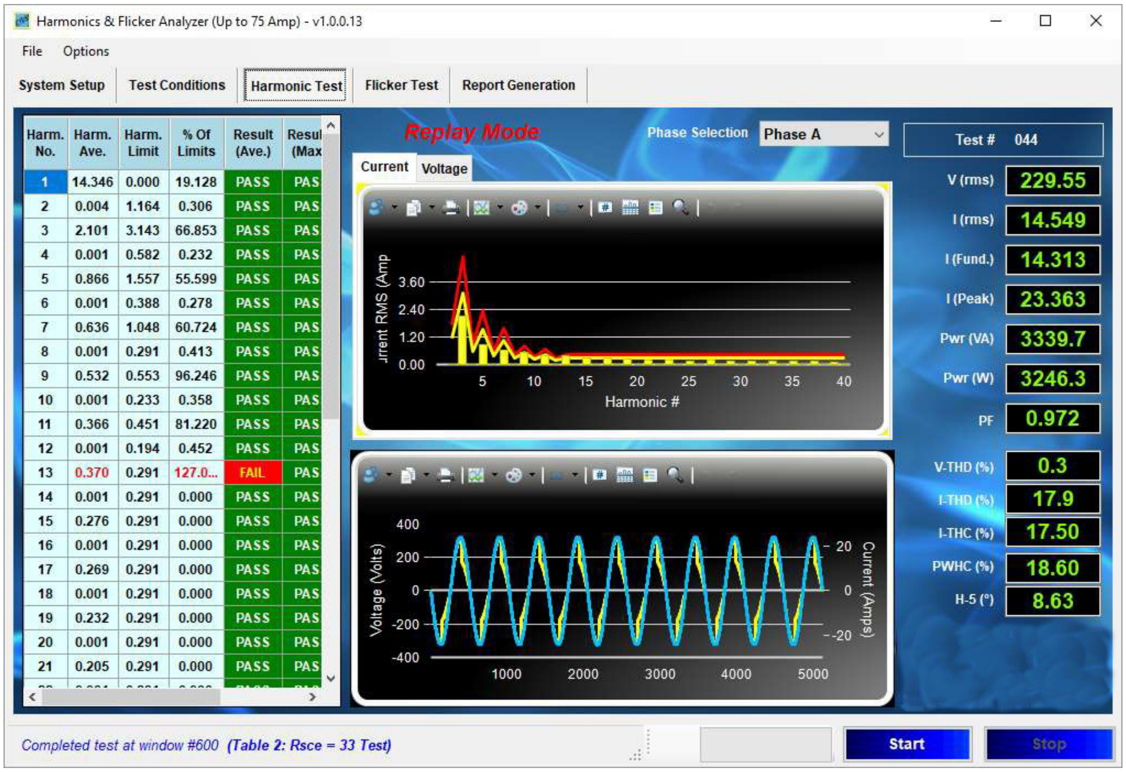
Figure 16 *Limits for balanced 3-phase equipment per Table-3*

Note that there are no limits for H_3 and H_9, asbalanced 3 phase equipment has in principleno odd triplen harmonics (3 – 9 – 15 – 21, etc.).

As with Table-2, the harmonic current emissions from H14 – H40 are taken into account in the THC and PWHC parameters in % of I-rms, which are computed using;

$$THC = \sqrt{\sum_{h=2}^{40} I_h^2} \qquad PWHC = \sqrt{\sum_{h=14}^{40} h \cdot I_h^2}$$

IEC 61000-3-12 Table-2 Test screen



Harm. No.	Harm. Ave.	Harm. Limit	% Of Limits	Result (Ave.)	Resul (Max
1	14.346	0.000	19.128	PASS	PAS
2	0.004	1.164	0.306	PASS	PAS
3	2.101	3.143	66.853	PASS	PAS
4	0.001	0.582	0.232	PASS	PAS
5	0.866	1.557	55.599	PASS	PAS
6	0.001	0.388	0.278	PASS	PAS
7	0.636	1.048	60.724	PASS	PAS
8	0.001	0.291	0.413	PASS	PAS
9	0.532	0.553	96.246	PASS	PAS
10	0.001	0.233	0.358	PASS	PAS
11	0.366	0.451	81.220	PASS	PAS
12	0.001	0.194	0.452	PASS	PAS
13	0.370	0.291	127.0...	FAIL	PAS
14	0.001	0.291	0.000	PASS	PAS
15	0.276	0.291	0.000	PASS	PAS
16	0.001	0.291	0.000	PASS	PAS
17	0.269	0.291	0.000	PASS	PAS
18	0.001	0.291	0.000	PASS	PAS
19	0.232	0.291	0.000	PASS	PAS
20	0.001	0.291	0.000	PASS	PAS
21	0.205	0.291	0.000	PASS	PAS

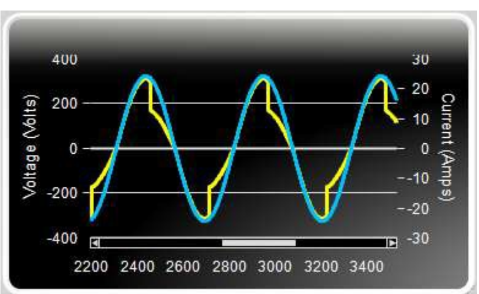
***Figure 17** IEC 61000-3-12 test per Table-2with a Rsce of 33*

As follows from the above test screen, harmonic 13 fails the limit by 27 %. If the user selects an Rsce of 66, the limit for H13 will be 3 % instead of the 2 % that applies for an Rsce of 33 (i.e 0.437 A). So, if the user defines a test for Rsce 66 for this equipment, it will pass (see the limits in the table per Figure 16).

For equipment that is rated > 16 Amp, but where the actual current is below 16 Amp (as in the above case) the user can opt the test per the applicable IEC 61000-3-12 limit table and Rsce, or test per IEC 61000-3-2 Class-A. In this case, it would not help to test per Class-A, as many of the higher order harmonics from H11 and up, would fail the Class-A limits. Therefore, testing with a Rsce of 66 is the best way to obtain a "PASS" for the product in question.

So, the general approach is to try to have the product PASS for the lowest Rsce.

IEC 61000-3-12 also has Table-4 and Table-5, with slightly relaxed limits for 3 phase equipment.



Those tables can be used if the product has a 5th harmonic that is in the rangefrom 90 – 150 degrees (Table-4) or 150 – 210 degrees (Table-5). Therefore, the analysis per IEC 61000-3-12 includes the 5th harmonic phase angle, 8.63 degrees in this case. Therefore, tables-4 or 5 are not applicable for this EUT. The "zoomed in" version of the current waveform (generated with a HFC-III calibrator) is shown in Figure 23.

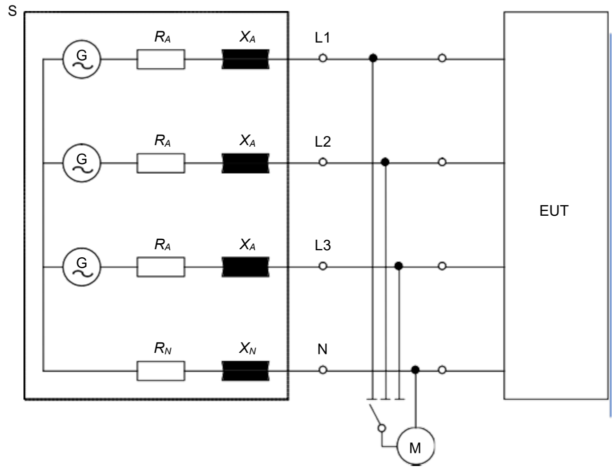
Figure 18 Zoomed in version of the waveform

IEC 61000-3-11 Flicker testing < 75 A (per phase)

The IEC 61000-3-11 standard is similar to the approach for IEC 61000-3-12, in that the user must determine the maximum permissible system impedance that the connection for the equipment is permitted to have.

Therefore, the connection is conditional upon the system impedance, not unlike the conditional connection that is determined by the Rsce for IEC 610003-12 testing. Equipment that fails the unconditional limits of IEC 61000-3-3, may also be tested per IEC 61000-3-11, and the maximum permitted system impedance can be determined.

Because of the higher current levels, the test impedance values are usually as defined for “Z-test” in the standard. The user may opt to have different impedance values, but the values below are recommended.



R_A = 0,15 Ω X_A = j 0,15 Ω

R_N = 0,10 Ω X_N = j 0,10 Ω.

Figure 19 *The Z-test for Flicker testing < 75 A-rms*

In principle, the measurements per IEC 61000-3-11 are very similar to the IEC 61000-3-3 test, except that the results are “calculated back” to the voltage fluctuations that the EUT would produce IF the test impedance were the Reference Impedance.

The resulting Flicker parameters can then be used to calculate the maximum permissible system impedance.

Evaluation against Z_{ref}

When using Z-test instead of Z_{ref}, the measured values shall be recalculated using the following formulae:

$$d_c = d_{c\ test} \cdot \frac{Z_{ref}}{Z_{test}}$$

$$d_{max} = d_{max\ test} \cdot \frac{Z_{ref}}{Z_{test}}$$

$$P_{st} = P_{st\ test} \cdot \frac{Z_{ref}}{Z_{test}}$$

$$P_{lt} = P_{lt\ test} \cdot \frac{Z_{ref}}{Z_{test}}$$

If Z-test equals the values given above in Figure 19, the ratio between Z-ref and Z-test is 1.6 for resistive loads, and 1.334 when comparing the complex impedance. Therefore, the measured Flicker parameters per IEC 61000-3-11, are normally recalculated i.e. are multiplied by 1.334. These recalculated values are then used to compute the maximum permissible system impedance for the EUT connection.

Calculating the maximum permissible connection impedance

To calculate the maximum permissible system impedance, Z_{sys}, the values of d_c, d_{max}, P_{st} and P_{lt} according to the above evaluation against Z_{ref}. are used in the following formulas.

$$Z_{sys1} = Z_{ref} \cdot \frac{(\text{The } d_{max} \text{ limit given in clause 5 appropriate to the EUT})}{d_{max}}$$

$$Z_{sys2} = Z_{ref} \cdot \frac{3{,}3\,\%}{d_c}$$

$$Z_{sys3} = Z_{ref} \cdot \left(\frac{1}{P_{st}}\right)^{\frac{3}{2}}$$

$$Z_{sys4} = Z_{ref} \cdot \left(\frac{0{,}65}{P_{lt}}\right)^{\frac{3}{2}}$$

The minimum of the four calculated values of Z_{sys} is the maximum permissible system impedance, Z_{max} which the manufacturer shall declare in accordance with the requirements per clause 4 of the standard.

For example, if the "dc" measurement per IEC 61000-3-11, using Z-test, equals 2.9 %, the recalculated "dc" will be 1.334 x 2.9 % = 3.87 %.

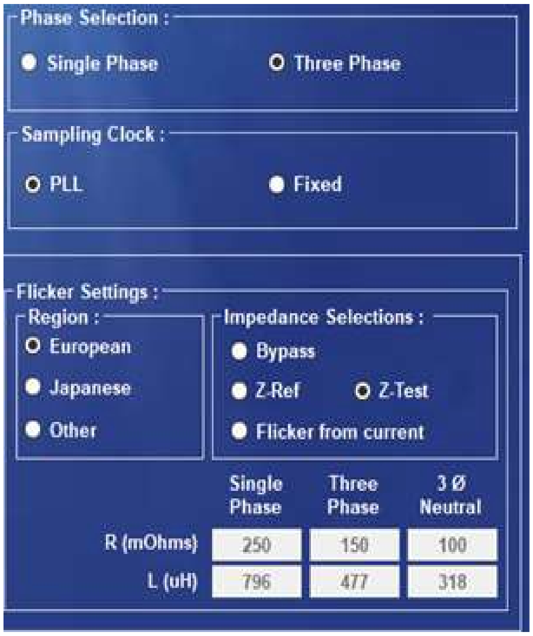
Consequently, the maximum permissible impedance for "dc" to remain below the 3.3 % limit, equals 3.3 / 3.87 x Zref i.e. maximum 341 mΩ resistive and j 0.213 Ω (679 µH). The 679 µH is generally divided between Line and Neutral per the same ratio in Zref, i.e 0.6 x 679 = 407 µH for the phase and 272 µH for the neutral conductor.

Note also, that if the EUT steady state current exceeds 19 A rms, the "dc" limit will be exceeded, even if we just use the resistive part of the impedance i.e 19 x 0.4 = 7.6 Volt rms, which equates 3.304 % for a 230 Volt nominal system.

Similarly, if the EUT exceeds 23 Amp for at least ½ cycle, (such as a motor start-up) the "dmax" will be exceeded or the Ref. Impedance, and the equipment must be connected at a point where the system impedance is lower.

The good news is that most European locations with underground cables, have an impedance that is generally only 60 – 70 % of the Ref. Impedance. Locations with overhead cables, or in older communities may have an impedance that equals (or even exceeds) the Reference Impedance values.

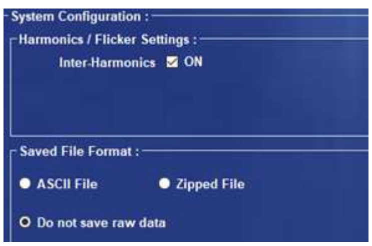
Flicker, sampling, grouping, and data storage setup



The system normally derives its sampling clock from the built-in PLL circuit. This circuit ensures that each 200 ms measurement window is perfectly synchronous with the 50.0x Hz or 60.0x Hz frequency from the power source, or public supply. The user can select "Fixed" for cases where a measurement must be made on a distorted public supply voltage, i.e. where the phase locked loop may have difficulties synchronizing to a noisy signal. The fixed sampling rate is 25600 Samples./sec. for 50 Hz systems and 30720 Samples./sec for 60 Hz (in both cases 512 samples cycle) - simultaneous for all channels.

If the system power source has a programmable impedance, the user can select this, and enter the values for inductance and resistance that need to be programmed in the source. The values for European and Japanese impedance types are pre-programmed to their default values. When measuring using the public supply, the Flicker can be calculated from the current (only for 1 phase).

Inter-harmonics (grouping) &(raw) data file format



Normally the system measures with Inter-Harmonics set to "On", i.e. the inter-harmonic frequencies are evaluated through the "grouping method" specified in IEC61000-4-7. As of this writing, this "grouping" is not yet mandatory, so theuser has the option to turn the inter-harmonics evaluation "off".

The system can store the raw data files in ASCII or in "zipped" format. ASCII is faster (as the zipping may take a minute or so) but the data files are big (100 Mbyte/minute). If you don't plan on keeping all the data files, the ASCII format is probably the preferred choice. As an alternate, you can turn the data storage "off" and only store data for a "final test" if so required.

Flicker measurement

If the user doesn't have a Reference Impedance or Programmable Impedance in the power source, the Flicker measurement can be based on current (per IEC 61000-3-3 Ed. 3 clause 5.1). That measurement is based on the calculation using the instantaneous current ***I (t)*** *and the Reference Impedance values.*

The harmonics test may be of a shorter duration than the 10 minute test time required obtain Pst, and Plt, The parameters "dc" – "dmax" – "Inst. Pst" and "T-max" are available to the user while the test progresses. Note that 3 phase Flicker from current cannot take the neutral into account, so it would not really be a complaint test, unless the EUT is perfectly balanced. Power sources with programmable impedance can be used for either 1 phase or 3 phase testing. Note, however that the power sources can only emulate the phase part of the impedance. Therefore, the programmable impedance can only be used for EUT's that are balanced i.e. do not have neutral current(s).

Note that balanced EUT's that have 3rd harmonic current emissions, may be balanced, but still have neutral current (with the 3 phases adding up in the neutral). In this case, an actual impedance box (also called lumped impedance that meets the requirements of Z-ref or Z-test (for higher currents) must be used.

The test conditions setup screen (HFa-3-36/75)

The user selects from one of the main three selections, being IEC 61000-3-12, or Flicker per IEC 61000-3-11. Depending on that choice, the selections in the field below the choice are used for the test. The bottom section of the setup windows lets the user select the voltage and frequency, select the test time, and enter further information.

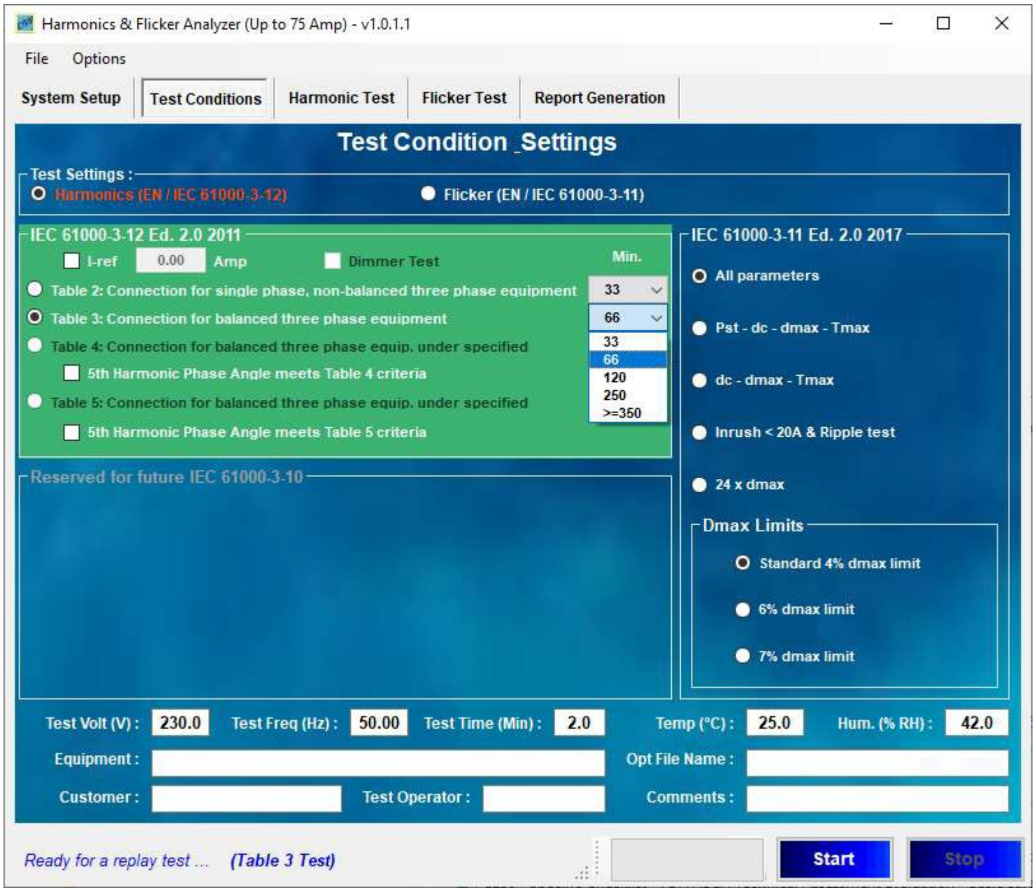


Figure 20 *Selecting aharmonics test class*

In this example, the system is set up for a test per Table-3 balanced equipment and a Rsce of 66.

As the test progresses, the system generates a “raw data file” much like a data logger does. This raw data file can be replayed, and re-analyzed at any time. In fact, the Harmonics Test Display page (fig. 23 page 23) shows the replay of the example file for a Table-2 R_{sce} = 120 that was run on a customer’s system during calibration verification of a HFa-3-75 at ATEC.

The user can enter an optional file name. If this field is left blank, the system generates a file name that includes the date, and a file sequence number (see Fig. 21 below). The sequence number simply increments, and the date precedes the sequence number.

For example, you may find data files as shown in the illustration below. The Raw Data sub-directory has these files. In the example below, the files are those that may come with your system installation if it can install the software on your PC, and run the calibration using it. The file names include the date the test was run, and then the sequence number. The file names can be changed as desired.

When re-playing a test, you can select from the raw data files, and run the test for any Table and Rsce

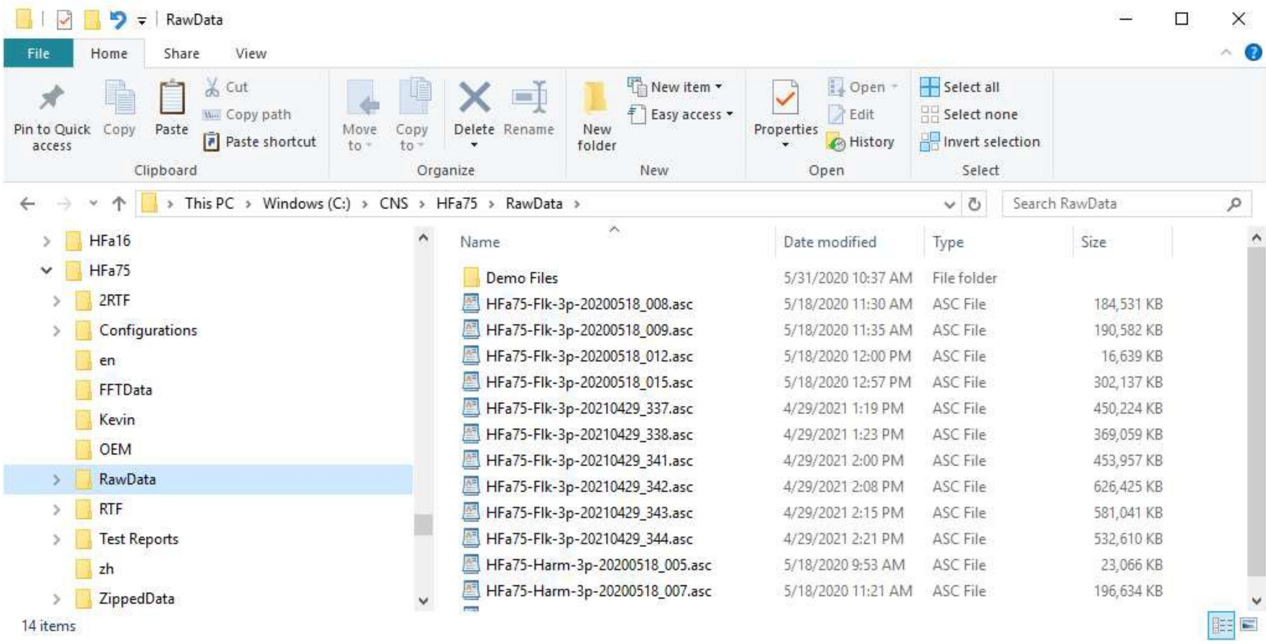


Figure 21 *Directory structure for raw data files in ASCII format*

When a test is completed, the system can be set to generate a zip (compressed) file from the raw data ASCII file. If the "zip" format is selected, and you close the program, it deletes the ASCII files, to save disk space. When you want to replay a "zip" data tests, you can select either the "asc" extension or the "zip" extension, and the system will automatically extract the file and run it.

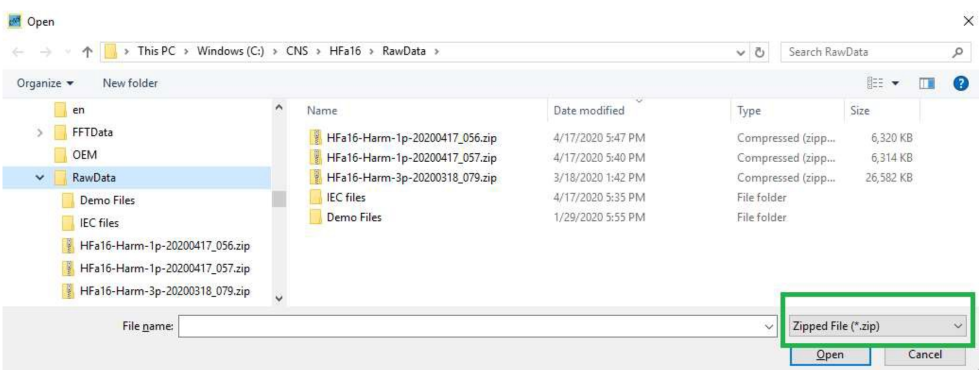
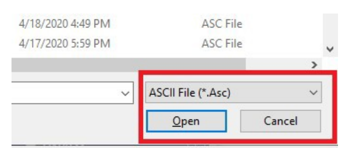


Figure 22 *Directory structure and selecting file format for ZippedData andASCII files*



The IEC 61000-3-12 Harmonics Test display

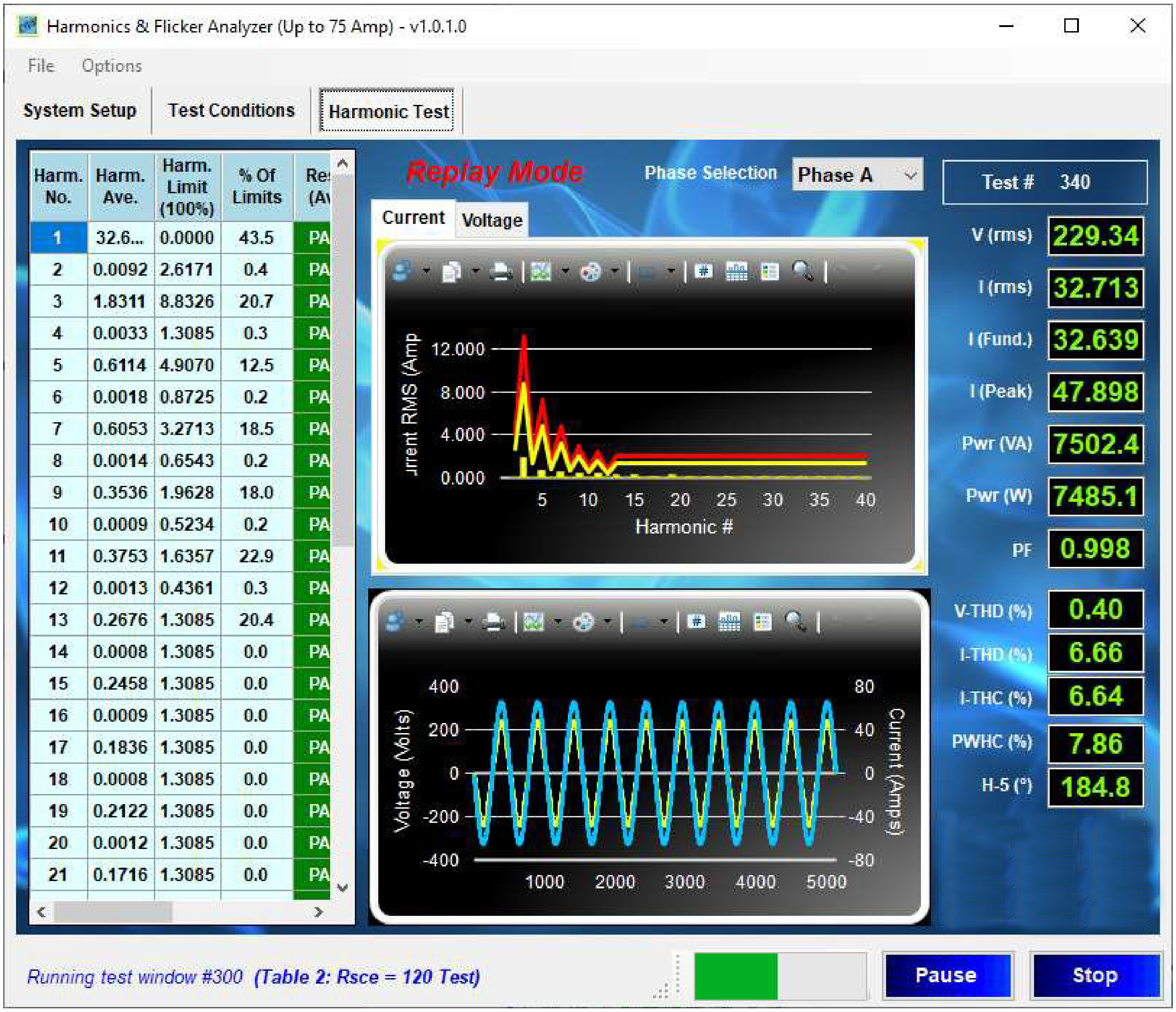


Figure 23 *The Table-2 Rsce 120 test display*

The IEC 61000-3-12 display example.

The leftmost columns display the current harmonics in numerical format, and show their absolute value as well as the percentage of limits and the PASS/FAIL condition. The "slider" below the data columns lets you move the display to the (maximum) values per measurement window. The HFa-3-75 display is "scalable" – so if you increase the display size, all the data columns become all visible (see the Figure 24 and the next two pages.

The top graph displays the harmonics (either current or voltage) in spectrum format, and optionally can also display the harmonics/emissions at frequencies from 2 – 9 kHz. The bottom graph displays the 10 / 12 cycles of 50 or 60 Hz that are measured in the 200 ms window. When you select the voltage spectrum display, the data columns display the power source quality parameters (distortion) in absolute V-rms, and in percent of the permitted distortion per IEC 61000-3-12. The classical power parameters are shown to the right. Note also, that the phase angle of H_5 is displayed, as well as the V-THD and I-THD, in addition to the required I-THC and POHC per IEC 61000-3-12. The POHC calculation is per IEC61000-3-2 method C.3.

The IEC 61000-3-12 Display (continued)

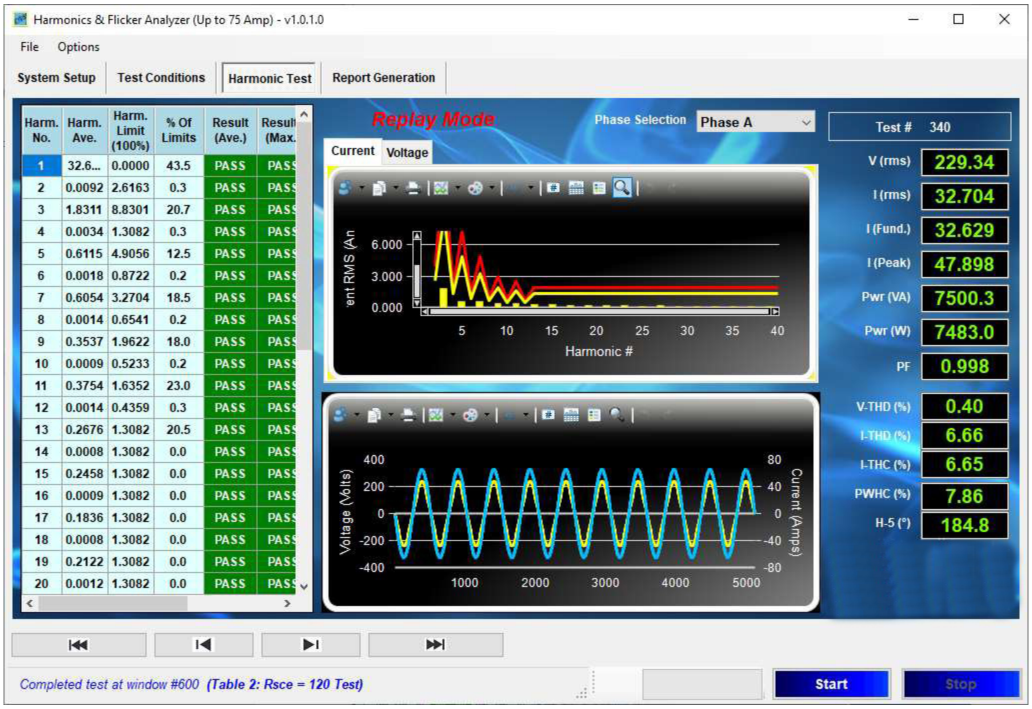


Figure 24 The grouped currentemissions and the top graph "zoomed in".

The top graph shows from H_0-H_{40} for a Table-2 test.

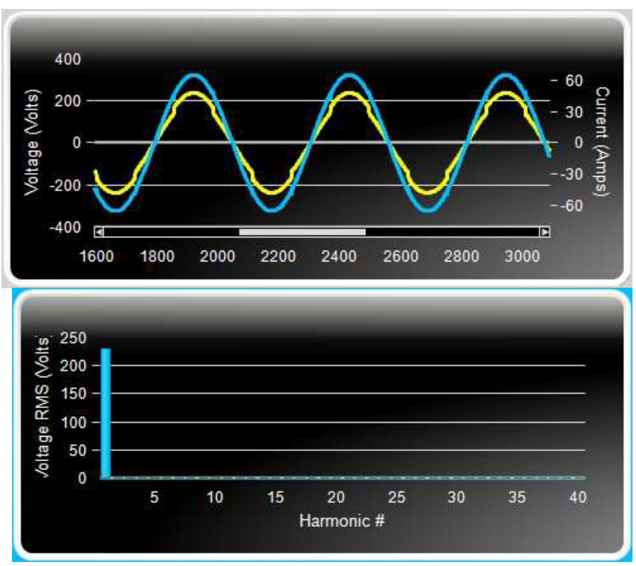


Figure 25 *The waveform graph zoomed to show just 3 cycles of the 200 ms data window, and selecting the voltage spectrum display with the voltage in numerical format to the left.*

The user can select the top graph display to be either the current or voltage harmonics from 2-40, or optionally the currents or voltages from 2 - 9 kHz.

The data grid to the left "switches along" with the graph selection. So, for harmonic currents from 2-40, the emission limits and status are displayed. When selecting the voltage harmonics from 2-40, the actual distortion and the permitted limits per IEC 61000-3-12 are displayed.

The IEC 61000-3-12 display in full screen mode

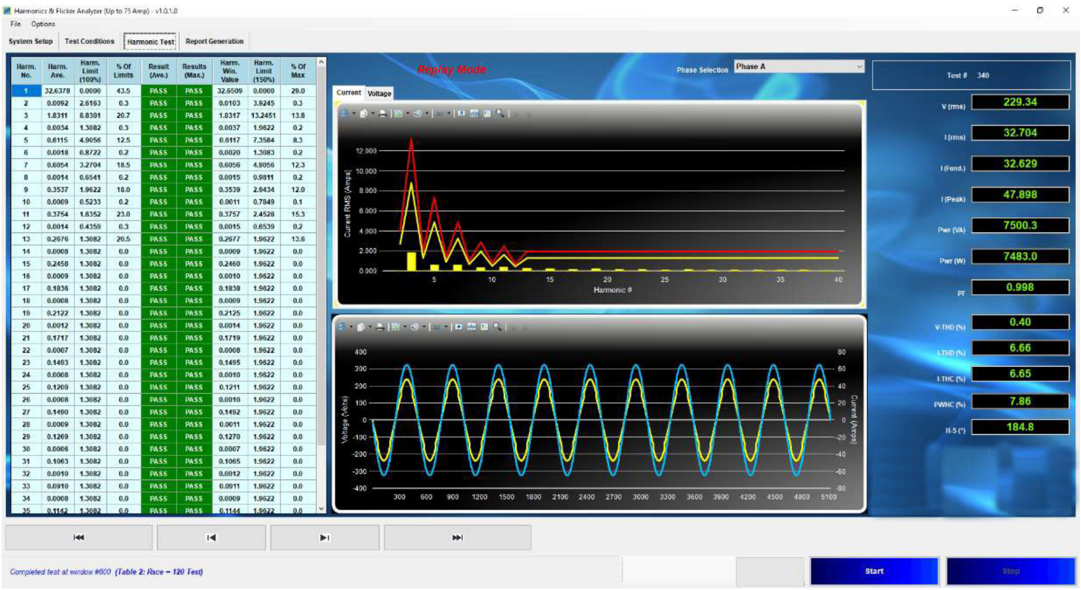


Figure 26 The Table-2 Rsce=120 display, "stretched"to include all data columns

For this Table-2 test, the HFC-III calibrator –in combination with a linear load - was set to produce a spectrum with some harmonics reaching around 20 % of the limits for Rsce=120. The leftmost columns display the current harmonics in numerical format, and show their percentage of limits as well as PASS/FAIL condition.

The HFa-3-75 display window was enlarged (maximized), so that the average harmonics, as well as the maximum individual window value against the 150 % limit are displayed. The numerical display is very helpful, as it is difficult - or sometimes impossible - to see in the spectrum graph, whether the higher order harmonics pass or fail. The first 3 columns on the left show the harmonic order, the (running) average of the harmonic current and the Pass/Fail status vs. the 100 % limits of the selected Table and R_{sce}. For this test, a R_{sce} of 120 was selected (see line 3 of Table-2 below). As emissions are only ~ 20 %, a lower R_{sce} can be selected, and the equipment will still pass.

With the scroll bar to the right of the data columns, one can move to the higher order harmonics. The IEC 610003-12 standard requires that the average of each harmonic is below the 100 % limit, but it also requires that the harmonics of individual 200 ms measurement windows, are below the maximum (150 %) limit. The 3 rightmost columns display the status vs. the 150 % maximum value, the maximum (filtered) value for individual measurement windows, and the percent of the maximum limit. The bottom graph shows the 10 cycles of the 200 ms measurement window. The user can zoom in on particular sections of either graph. It is also possible to copy the graphs and past them into a document or print them out directly – see the next page.

Table 2 – Current emission limits for equipment other than balanced three-phase equipment

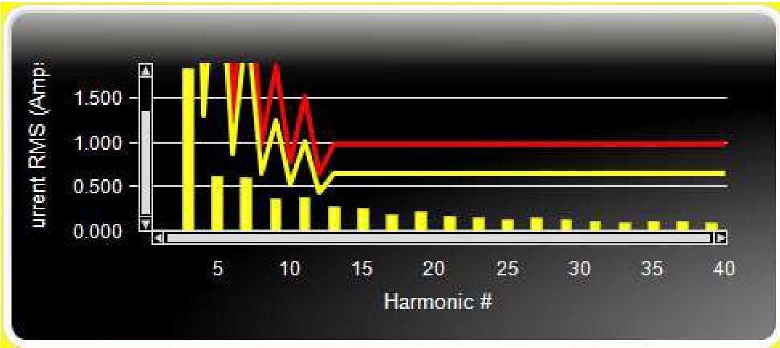
Minimum R_{sce}	Admissible individual harmonic current I_h/I_{ref} [a] %						Admissible harmonic parameters %	
	I_3	I_5	I_7	I_9	I_{11}	I_{13}	THC/I_{ref}	$PWHC/I_{ref}$
33	21,6	10,7	7,2	3,8	3,1	2	23	23
66	24	13	8	5	4	3	26	26
120	27	15	10	6	5	4	30	30
250	35	20	13	9	8	6	40	40
≥350	41	24	15	12	10	8	47	47

The relative values of even harmonics up to order 12 shall not exceed 16/h %. Even harmonics above order 12 are taken into account in THC and $PWHC$ in the same way as odd order harmonics.

Linear interpolation between successive R_{sce} values is permitted.

[a] I_{ref} = reference current; I_h = harmonic current component.

Table-2 from IEC 61000-3-12



One can simply copy the graphs to either the Windows Clipboard, as a bitmap, for inclusion into reports, such as was done for the current in Fig. 27. The vertical scale of the top spectrum graph was scaled, based on the “selected zoom” level, in this case about 1.75 A.

***Figure 27** The "zoomed in" current spectrum*

The waveform graph displays the same data as shown in the Fig. 24 screen shot, but with some different settings. The “zoom level” determines the axis to show the waveform in more detail. The “slider” below and on the side of the graph is used to “zoom in” on a particular section of the 10 windows. Whatever is displayed is copied. The user can move around the (200 ms – 10 cycle) graph with the scrollbars or sliders at the bottom and left-hand side of the graph, and zoom in as required.

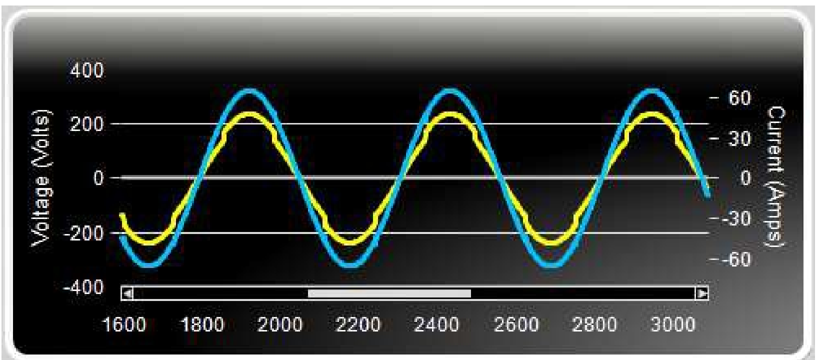


***Figure 28** The "zoomed in" waveform graph display*

When selecting the voltage spectrum graph, one can zoom in, so that low level voltage harmonics are better visible. Thus, one can see the voltage distortion components in detail, as shown to the left, with H_3 at about 0.6 V-rms, or 0.25 % of the 230 Volt fundamental.

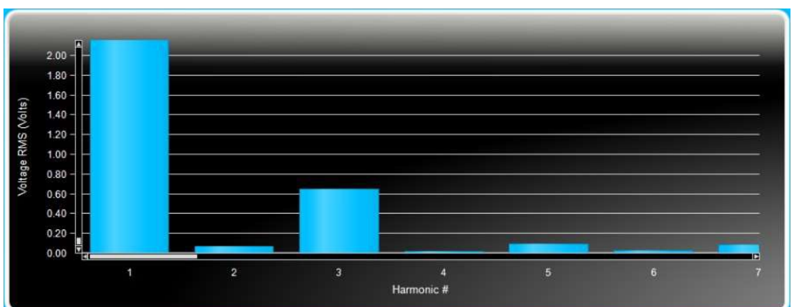


***Figure 29** The voltage spectrum (distortion) in detail*

To copy a graph, click on the “two pages” icon, to the left of the printer icon, and select the copy format. The text format lets you copy data into aspreadsheet.

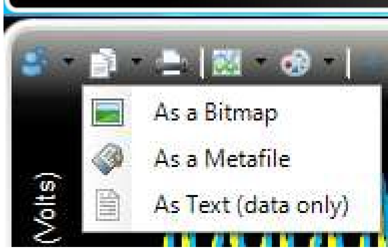


***Figure 30** Selecting the voltage spectrum (distortion) as a bitmap*

The Harmonics Table-2 Rsce 33 Test Report

The general test data for just Phase-A is shown in this and the next 2 pages. Note that the graphs are shown as they are left in the main HFa75 display. Phase-B & C have a similar format.

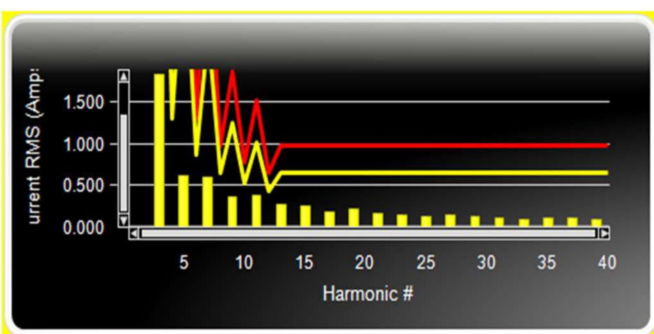
Test File:	**H-20210516_ 340**
EUT:	**HFC-III**
Test Class:	**(Table 2: Rsce = 33 Test), IEC 61000-3-12 Ed. 2.0 2011**
Test Result:	**PASS**
Test Date:	**4/29/2021**
Start Time:	**1:47:45**
Stop Time:	**1:49:57**
Test Duration (min):	**2**

Source Qualification:	**Compliance with IEC 61000-3-12 Ed. 2.0 2011**
Power Source Distortion:	**OK**
Customer:	
Test By:	
Comments:	

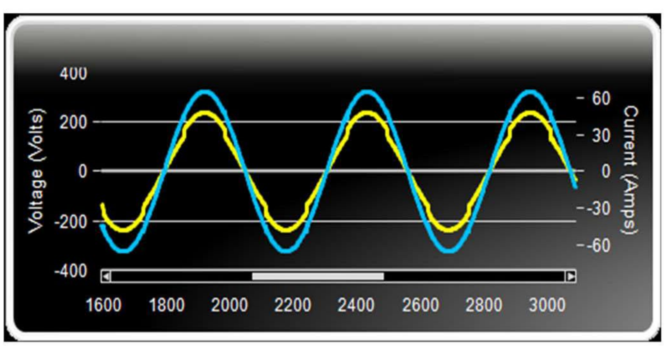
General Test Data: (Phase A)

Vrms (Volts):	**229.34**	**Frequency (Hz):**	**50.00**
I-ref (Amps):	**32.704**	**Power (VA):**	**7500.3**
I_fund (Amps):	**32.629**	**Power (W):**	**7483.0**
I_peak (Amps):	**47.898**	**Power Factor:**	**0.998**
V-THD (%):	**0.40**	**I-THD (%):**	**6.66**
I-THC (%):	**6.65**	**I-THC Limit (%):**	**23.00**
PWHC (%):	**7.86**	**PWHC Limit (%):**	**23.00**
Measured I-Ref (A):	**32.704**	**Measured I-Ref was used for this test.**	
Phase angle of H5 (deg):	**184.8**		

Harmonic Spectrum



Voltage & Current Waveform



Current Harmonics (averaged & max window values at the end of test)

Harm No.	Harm. Ave.	Harm. Limit (100%)	% Of Limits	Result (Ave.)	Result (Max.)	Harm. Win.	Harm. Limit (150%)	% Of Max
2	0.0092	2.6163	0.3	PASS	PASS	0.0103	3.9245	0.3
3	1.8311	7.0641	25.9	PASS	PASS	1.8317	10.5961	17.3
4	0.0034	1.3082	0.3	PASS	PASS	0.0037	1.9622	0.2
5	0.6115	3.4993	17.5	PASS	PASS	0.6117	5.2490	11.7
6	0.0018	0.8722	0.2	PASS	PASS	0.0020	1.3083	0.2
7	0.6054	2.3547	25.7	PASS	PASS	0.6056	3.5320	17.1
8	0.0014	0.6541	0.2	PASS	PASS	0.0015	0.9811	0.2
9	0.3537	1.2428	28.5	PASS	PASS	0.3539	1.8641	19.0
10	0.0009	0.5233	0.2	PASS	PASS	0.0011	0.7849	0.1
11	0.3754	1.0138	37.0	PASS	PASS	0.3757	1.5207	24.7
12	0.0014	0.4359	0.3	PASS	PASS	0.0015	0.6539	0.2
13	0.2676	0.6541	40.9	PASS	PASS	0.2677	0.9811	27.3
14	0.0008	0.6541	0.0	PASS	PASS	0.0009	0.9811	0.0
15	0.2458	0.6541	0.0	PASS	PASS	0.2460	0.9811	0.0
16	0.0009	0.6541	0.0	PASS	PASS	0.0010	0.9811	0.0
17	0.1836	0.6541	0.0	PASS	PASS	0.1838	0.9811	0.0
18	0.0008	0.6541	0.0	PASS	PASS	0.0009	0.9811	0.0
19	0.2122	0.6541	0.0	PASS	PASS	0.2125	0.9811	0.0
20	0.0012	0.6541	0.0	PASS	PASS	0.0014	0.9811	0.0
21	0.1717	0.6541	0.0	PASS	PASS	0.1719	0.9811	0.0
22	0.0007	0.6541	0.0	PASS	PASS	0.0008	0.9811	0.0
23	0.1493	0.6541	0.0	PASS	PASS	0.1495	0.9811	0.0
24	0.0008	0.6541	0.0	PASS	PASS	0.0010	0.9811	0.0
25	0.1209	0.6541	0.0	PASS	PASS	0.1211	0.9811	0.0
26	0.0008	0.6541	0.0	PASS	PASS	0.0010	0.9811	0.0
27	0.1490	0.6541	0.0	PASS	PASS	0.1492	0.9811	0.0
28	0.0009	0.6541	0.0	PASS	PASS	0.0011	0.9811	0.0
29	0.1269	0.6541	0.0	PASS	PASS	0.1270	0.9811	0.0
30	0.0006	0.6541	0.0	PASS	PASS	0.0007	0.9811	0.0
31	0.1063	0.6541	0.0	PASS	PASS	0.1065	0.9811	0.0
32	0.0010	0.6541	0.0	PASS	PASS	0.0012	0.9811	0.0
33	0.0910	0.6541	0.0	PASS	PASS	0.0911	0.9811	0.0
34	0.0008	0.6541	0.0	PASS	PASS	0.0009	0.9811	0.0
35	0.1142	0.6541	0.0	PASS	PASS	0.1144	0.9811	0.0
36	0.0008	0.6541	0.0	PASS	PASS	0.0010	0.9811	0.0
37	0.0997	0.6541	0.0	PASS	PASS	0.0998	0.9811	0.0
38	0.0008	0.6541	0.0	PASS	PASS	0.0009	0.9811	0.0
39	0.0827	0.6541	0.0	PASS	PASS	0.0828	0.9811	0.0
40	0.0007	0.6541	0.0	PASS	PASS	0.0008	0.9811	0.0

Power Source Verification Data per IEC 61000-3-12

Harm No.	Harm. Value	Harm. Limit	% Of Limits	% Of Vfund	Result
2	0.0537	0.9200	5.8	0.023	OK
3	0.0881	2.8750	3.1	0.038	OK
4	0.0190	0.9200	2.1	0.008	OK
5	0.0524	3.4500	1.5	0.023	OK
6	0.0122	0.9200	1.3	0.005	OK
7	0.4131	2.8750	14.4	0.180	OK
8	0.0111	0.9200	1.2	0.005	OK
9	0.3701	1.3800	26.8	0.161	OK
10	0.0052	0.9200	0.6	0.002	OK
11	0.0408	1.6100	2.5	0.018	OK
12	0.0087	0.6900	1.3	0.004	OK
13	0.0606	1.3800	4.4	0.026	OK
14	0.0052	0.6900	0.8	0.002	OK
15	0.3644	0.6900	52.8	0.159	OK
16	0.0075	0.6900	1.1	0.003	OK
17	0.3181	0.6900	46.1	0.139	OK
18	0.0045	0.6900	0.6	0.002	OK
19	0.0551	0.6900	8.0	0.024	OK
20	0.0087	0.6900	1.3	0.004	OK
21	0.0494	0.6900	7.2	0.022	OK
22	0.0051	0.6900	0.7	0.002	OK
23	0.2769	0.6900	40.1	0.121	OK
24	0.0056	0.6900	0.8	0.002	OK
25	0.2552	0.6900	37.0	0.111	OK
26	0.0082	0.6900	1.2	0.004	OK
27	0.0745	0.6900	10.8	0.033	OK
28	0.0065	0.6900	0.9	0.003	OK
29	0.0684	0.6900	9.9	0.030	OK
30	0.0034	0.6900	0.5	0.001	OK
31	0.2270	0.6900	32.9	0.099	OK
32	0.0052	0.6900	0.8	0.002	OK
33	0.2067	0.6900	30.0	0.090	OK
34	0.0055	0.6900	0.8	0.002	OK
35	0.0809	0.6900	11.7	0.035	OK
36	0.0043	0.6900	0.6	0.002	OK
37	0.0818	0.6900	11.9	0.036	OK
38	0.0046	0.6900	0.7	0.002	OK
39	0.1905	0.6900	27.6	0.083	OK
40	0.0066	0.6900	1.0	0.003	OK

The Flicker test conditions selection

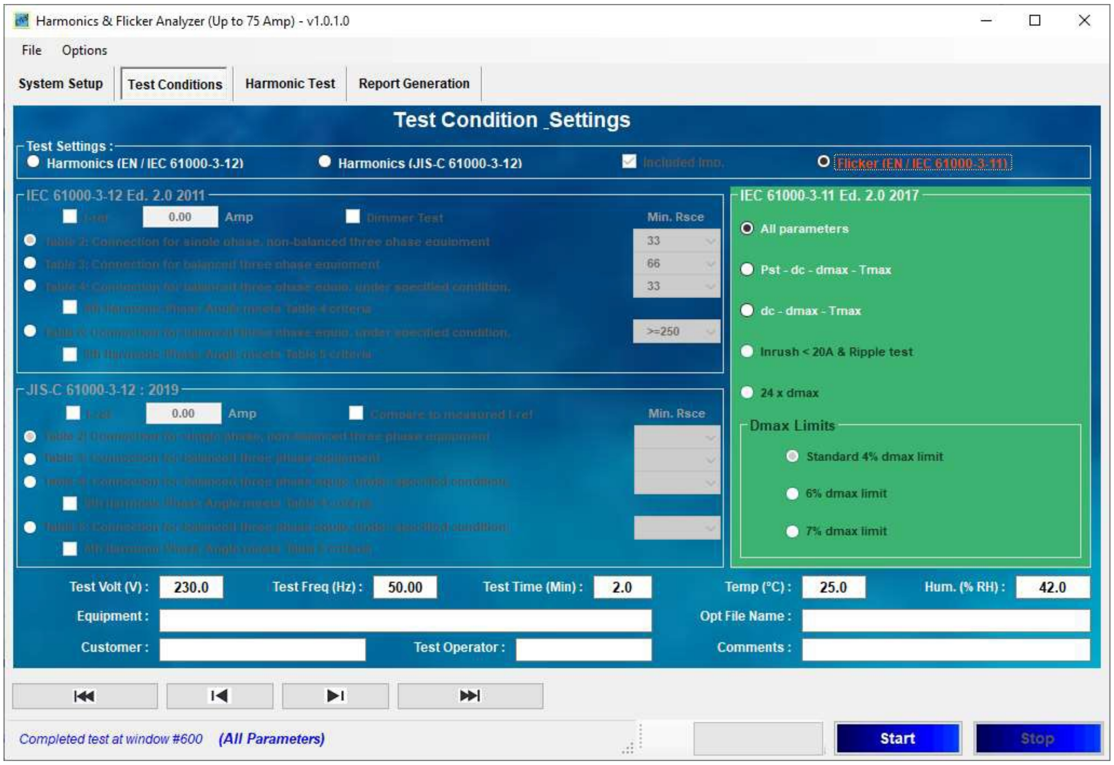


Figure 31 *The Flicker testsetup screen*

There are a number of possible tests that a user can select from. Generally, the “All parameters” selection can be made. Since IEC 61000-3-11 can also be used for products below 16 Amp/phase (that do not meet IEC 61000-3-3), the test conditions of IEC 61000-3-3 may apply. For some products (so-called brown goods, like audio equipment, gaming products), only “dc-dmax-Tmax” are required. This also applies for vacuum cleaners, and food mixers. For a number of products with relatively short operating cycles, Pst-dc-dmax-Tmax is the correct choice. So, no Plt evaluation for portable tools, cookers, refrigerators, and hair dryers.

The user must select a dmax limit, and 4 % is the default or “safe choice”. For equipment that is switched manually, or automatically more often than 2 x per day (Air conditioners), the 6 % limit may be selected (and the 24 x dmax procedure can be followed). The 7 % applies to equipment that is attended whilst in use, such as portable tools and welders.

For air conditioners, the user may select the 24 x dmax test. The procedure for this test is specified in Annex B of IEC 61000-3-3 and referenced in IEC 611000-3-11. The sequence is; Start the measurement with the EUT turned “off”, then turn it “on” for 1 minute. Next – turn the unit off until the unit has no moving parts, and any “d-max mitigation” device hascooled down. Then start the next measurement, and repeat the sequence 24 times. Next remove the highest and lowestobserved dmax value, and take the average of the remaining 22.

In principle, the test per IEC 61000-3-11 will result is a “maximum connection impedance” where the tested product may be used. A product that meets IEC 61000-3-3 can be used anywhere, but when it doesn’t meet IEC 61000-3-3, it requires a lower impedance at the connection point, and determining that impedance is the purpose of IEC 61000-3-11. The Flicker measurement Display

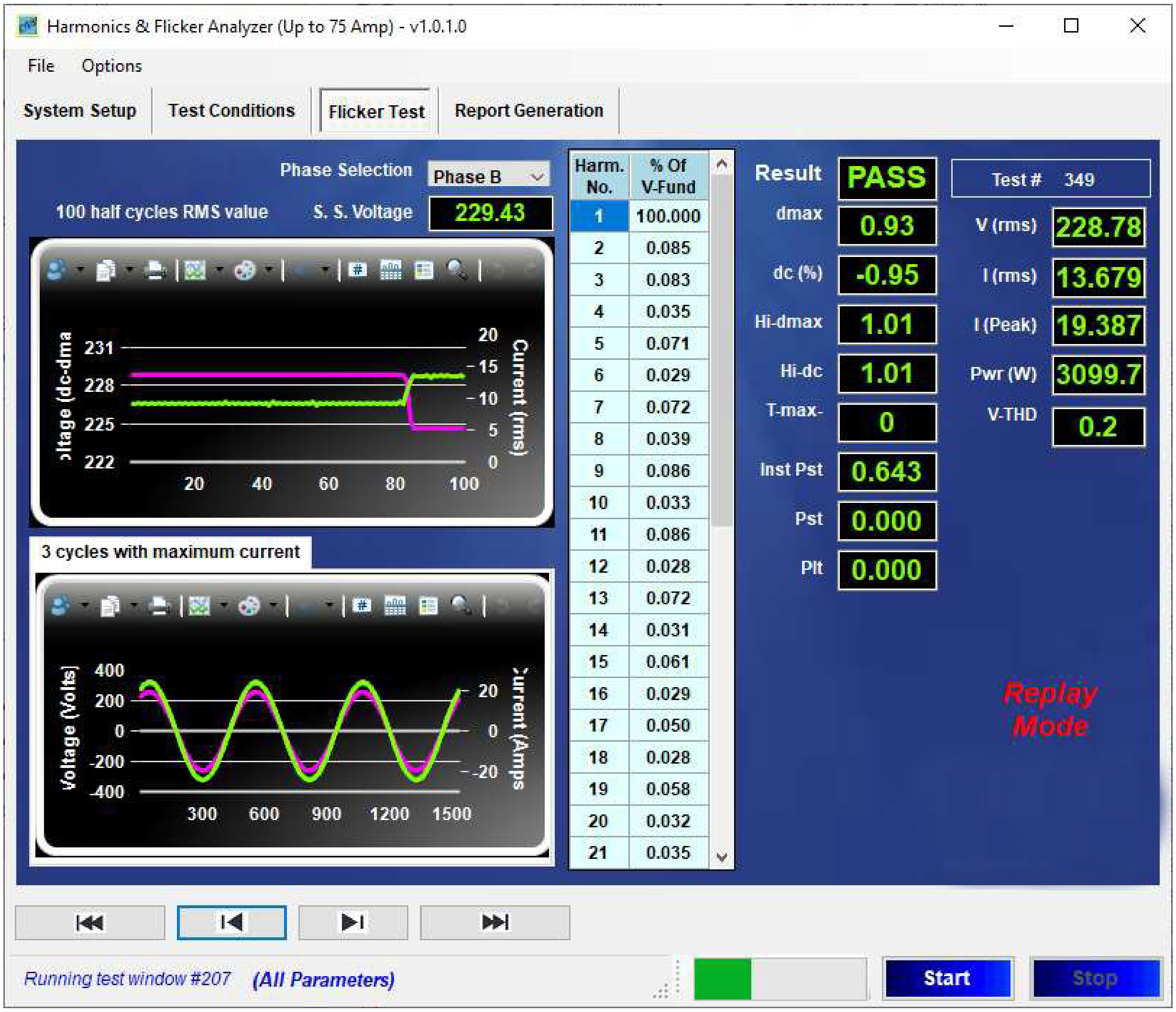


Figure 32
TheFlicker test screen

The above Flicker measurement display for “All parameters” is “real time”, i.e. the display is updated every second. Thetop graph displays the voltage in V-rms per half cycle i.e. 100 ea. values per second (horizontal scale), as well as the 100 half cycle rms values for current per second. In this case, phase B is selected to be displayed. The Hi-dc and Hi- dmax show the maximum values that have occurred in the test up to that time. The “Inst Pst” is the calculated Pst valueup to that time. It requires 10 minutes to obtain a Pst and Plt value (the standard specifies an observation time of 10 minutes).

In the above example, the load is turned “Off” (the violet trace jumps down from 13.7 A-rms to 5.3 Amp). This causes the voltage change of about 1.0 % When this load pattern is turned On/Off every ~ 7.8 seconds, the resulting Pst will be ~ 0.64 when using the Z-test impedance. **The “Inst. Pst” parameter is updated (integrated per IEC 61000-4-15) every second**, and at the end of 10 minutes, this results in a Pst value.

Of course, the other parameters are updated every second also. The system also monitors the voltage THD (the standard requires the V-THD to be less than 3 %), as well as the power and the rms current level. So, a 10 minute test MUST be completed to get a Pst value.

Note also, that the system keeps track of the ***last measured Steady State voltage***.

The Flicker measurement Display (cont.)

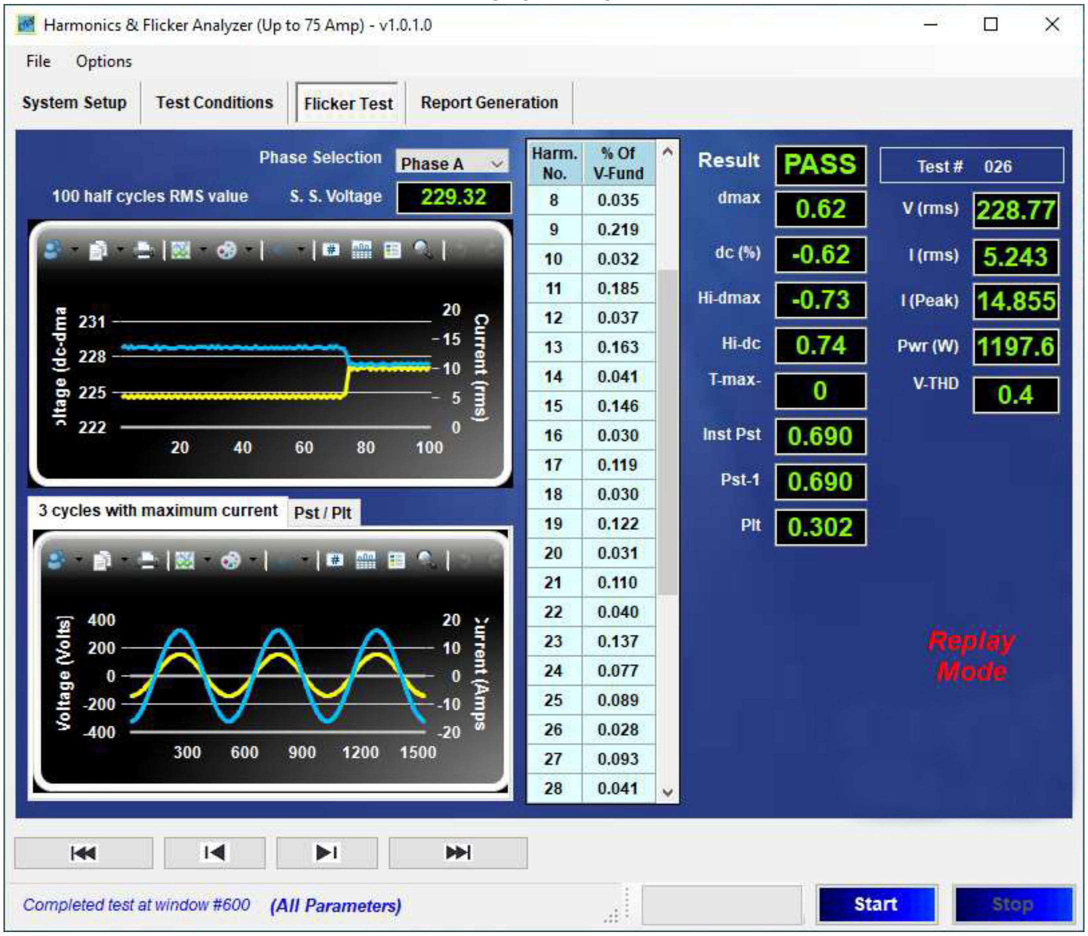
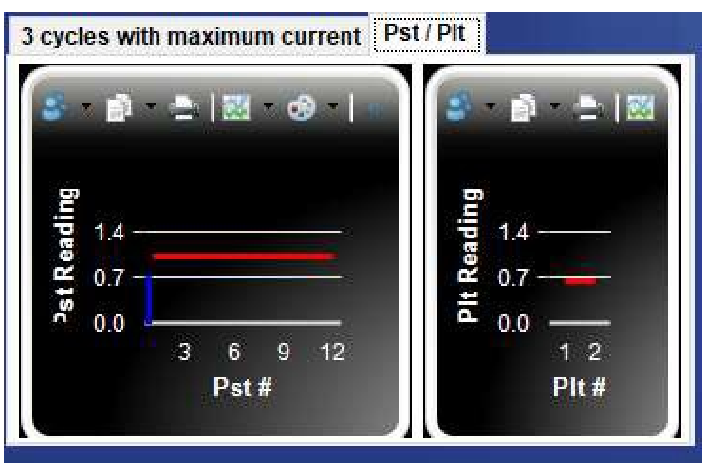


Figure 33 10 minute Flicker test with 0.325 Hz modulation for Phase-A

The above screen shot (replay of test 026) illustrates the 0.325 Hz modulation pattern (part of the Table 5 calibration points in IEC 61000-4-15). At 0.325 Hz, there is a transition every 545 ms i.e. the current is turned "On" or "Off" every 0.545 seconds. As the current is turned "On" there is a voltage drop through the Reference Impedance that is proportional to the amount of current, and thus the voltage fluctuation is inversely proportional to the current flow. The bottom graph shows a few periods where the load (current) is turned "On". Given the small drop of about 1.4 Volts, theexact change is very difficult (if not impossible) to discern from the voltage. The relative drop, however, along with the modulating current (top graph) easily illustrate the pattern. The data grid shows the voltage harmonics, and the variousflicker parameters are to the right. For Flicker tests, the V-THD (voltage distortion) must be < 3 %. Given that the Pst is0.69, the test result after 10 min. is PASS, and the Plt computes to 0.302.



If you click on the little Pst / Plt tab, the graphs, for Pst and Plt are shown (just one value in this case).

The Flicker measurement display (cont.)

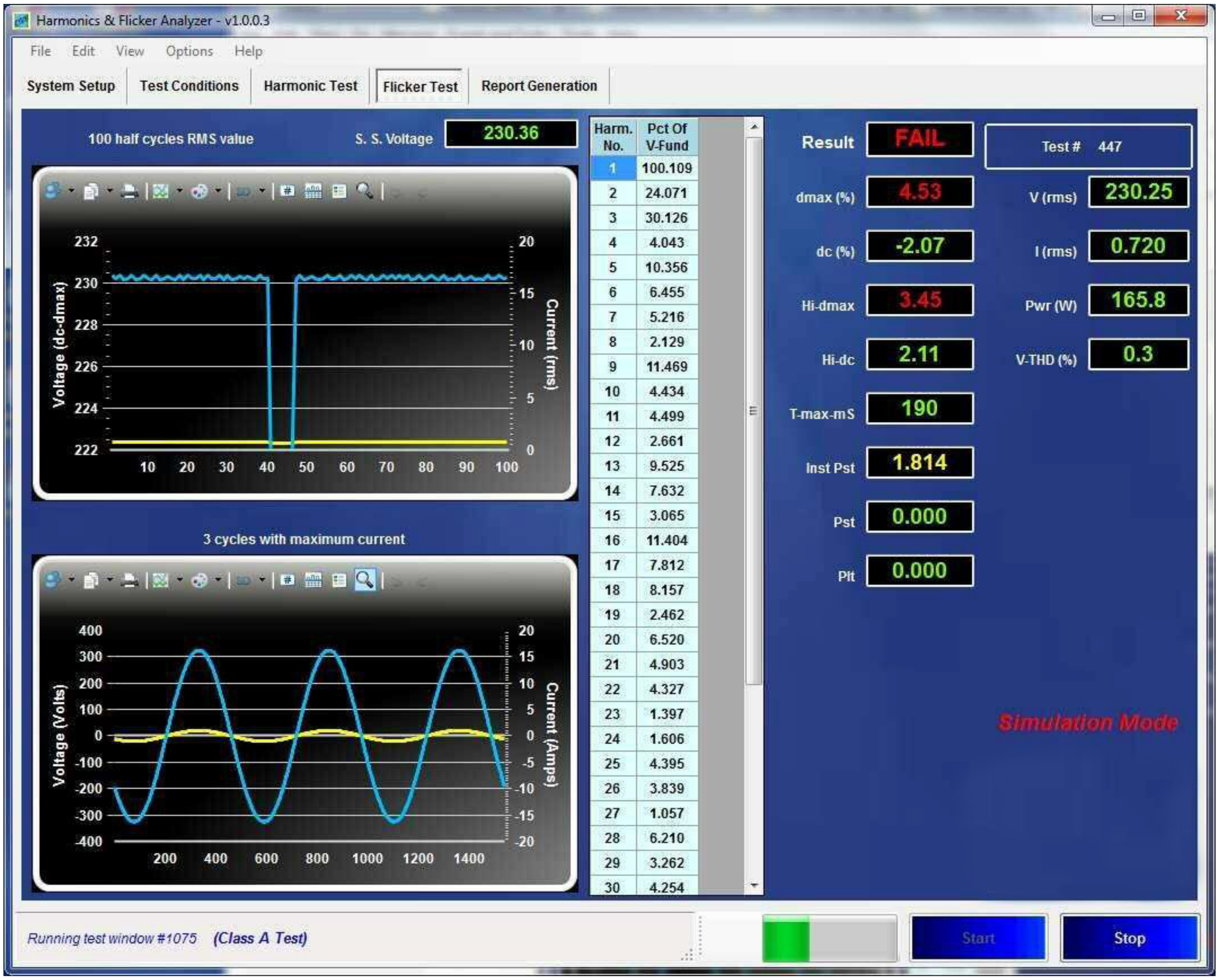
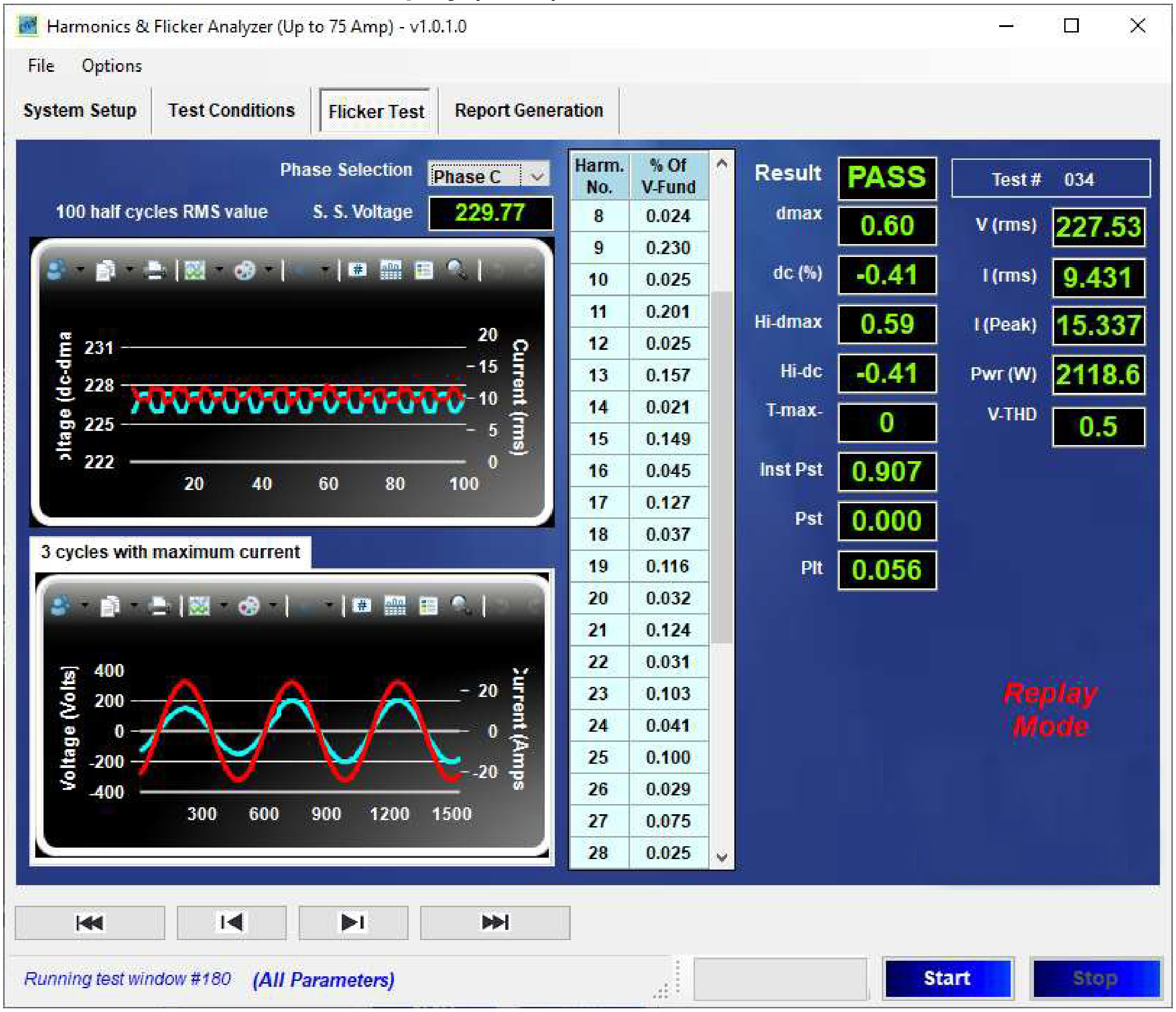


Figure 34 *dmax exceeding the limit, and T- max of 190 ms*

For the above screen shot, the power source was programmed to simulate a brief voltage drop (190 ms) of about 4.5 % and the display was recorded just before the “Hi-dmax” and several other parameters were updated. T-max is the time that a voltage dip duration exceeds a 3.3 % drop. The standard limits this duration (T-max) to 500 ms, so that the parameter with 190 ms still is within the maximum permitted time.

The limit for “dmax” however, is 4 % (for most equipment) and the measured value for this maximum voltage drop was 4.53 % and therefore the EUT would FAIL the Flicker test.

The Flicker measurement display (cont.)



Harm. No.	% Of V-Fund
8	0.024
9	0.230
10	0.025
11	0.201
12	0.025
13	0.157
14	0.021
15	0.149
16	0.045
17	0.127
18	0.037
19	0.116
20	0.032
21	0.124
22	0.031
23	0.103
24	0.041
25	0.100
26	0.029
27	0.075
28	0.025

Figure 35 *Modulation at 13.5 Hz applied to Phase-C*

The above screen shot illustrates a modulation pattern at the 13.5 Hz modulation. At 13.5 Hz (1620 changes per minute for rectangular voltage changes) even a small 0.407 % voltage modulation will produce a Pst level of 1.00. This screen shot was taken after 5 minutes or so, prior to a full 10 min. Pst value.

Page 32 shows the report for a Flicker test that was done, using the calculation from the instantaneous current level I_t (@ 256 samples per ½ cycle).

The following page shows the “24 x dmax” test example using 61000-3-3), and page 33 shows an example test report.

The 24 x dmax test

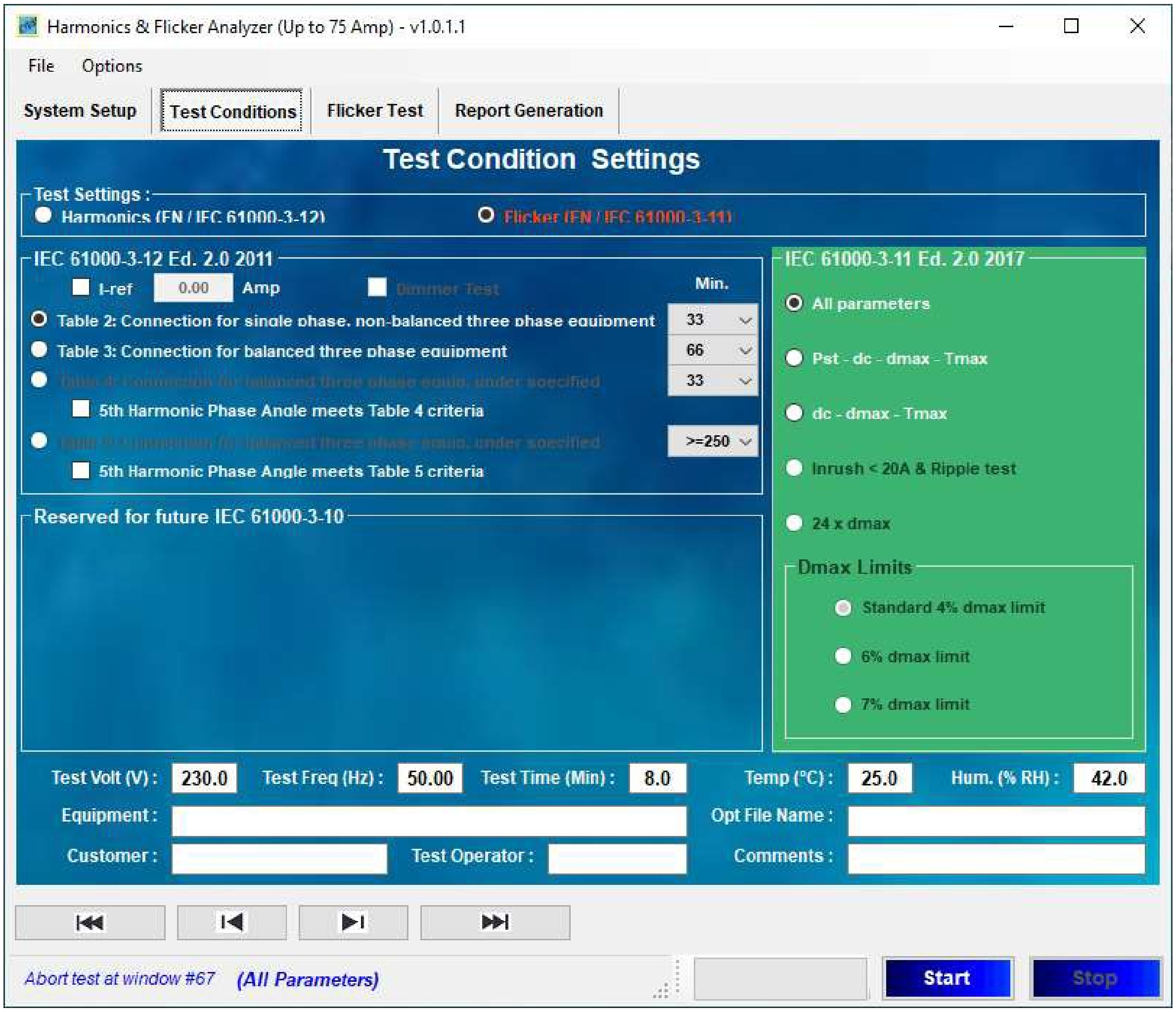


Figure 36 Flicker test selection with the 4 % standard dmax limit

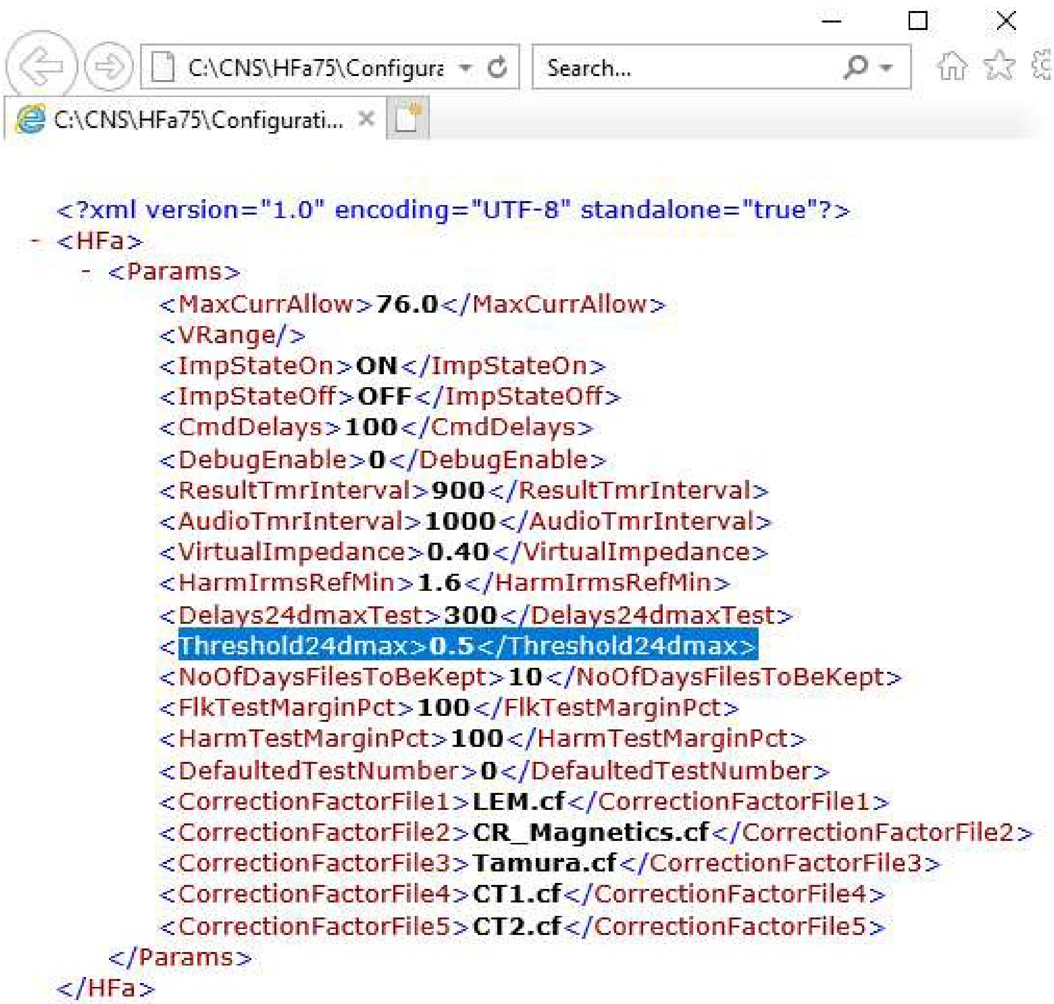
When the user selects the 24 x dmax test, and then clicks on "Start", the system will display a sub-window, giving instructions. The system wants you to ensure that the EUT is "off".

Figure 37 *User prompts for 24 x dmax testing*

When the current level is below 0.5 A rms, the unit is considered to be "off". Conversely, when the current is > 0.5 A rms, the unit is considered to be "on".

In case the EUT has a standby current that is higher – or has a current level that is below 0.5 A rms, when the unit is turned "on". The user can edit the file called "Misc_Parameters.xml, in the directory as shown on the next page, i.e.

C:\CNS\HFa75\Configurations\System\Misc\Misc_Parameters.xml



```xml
<?xml version="1.0" encoding="UTF-8" standalone="true"?>
- <HFa>
  - <Params>
      <MaxCurrAllow>76.0</MaxCurrAllow>
      <VRange/>
      <ImpStateOn>ON</ImpStateOn>
      <ImpStateOff>OFF</ImpStateOff>
      <CmdDelays>100</CmdDelays>
      <DebugEnable>0</DebugEnable>
      <ResultTmrInterval>900</ResultTmrInterval>
      <AudioTmrInterval>1000</AudioTmrInterval>
      <VirtualImpedance>0.40</VirtualImpedance>
      <HarmIrmsRefMin>1.6</HarmIrmsRefMin>
      <Delays24dmaxTest>300</Delays24dmaxTest>
      <Threshold24dmax>0.5</Threshold24dmax>
      <NoOfDaysFilesToBeKept>10</NoOfDaysFilesToBeKept>
      <FlkTestMarginPct>100</FlkTestMarginPct>
      <HarmTestMarginPct>100</HarmTestMarginPct>
      <DefaultedTestNumber>0</DefaultedTestNumber>
      <CorrectionFactorFile1>LEM.cf</CorrectionFactorFile1>
      <CorrectionFactorFile2>CR_Magnetics.cf</CorrectionFactorFile2>
      <CorrectionFactorFile3>Tamura.cf</CorrectionFactorFile3>
      <CorrectionFactorFile4>CT1.cf</CorrectionFactorFile4>
      <CorrectionFactorFile5>CT2.cf</CorrectionFactorFile5>
    </Params>
</HFa>
```

Figure 38 *The Misc_Parameters.xml file with 24x dmax threshold highlighted*

Of course, the user must show what Flicker test method was used, and this is reflected in the test report. The next page shows an example for a report for a “All parameters” test.

Note that there will be NO value for Pst or a Pst graph, if the user doesn’t let a 10 minute test complete. So, for “All parameters” – the test time must at least be 10 minutes.

For longer tests, with multiple Pst periods, the report will show the Pst value for each 10 minute measurement period.

Page 37 shows the data for a 3 phase test that was stopped after 3 minutes. Page 38 -40 show a 3 phase report with a fluctuating load mainly on Phase-A, with Phase B showing about ½ of Phase-A, and Phase-C about 1/6th.

Page 41 shows a “24xdmax” test report, and page 42 illustrates the simplified “< 20 Amp inrush and < 1.5 amp ripple current” report.

Page 43 shows a report for the simple < 20 Amp inrush and < 1.5 A ripple current, that fails, because the ripple current is more than 1.5 Amp. This is not to say that the Flicker test fails, it may very well pass the “All parameters” test. It’s just that one canot use the simplified test for this EUT. Generally, the simplified test will not be used in IEC 61000-3-11, as the current will usually be > 20 Amp.

The Flicker test report

The report below is for 3 phases, for a test of just 8 minutes, i.e. NO graphs and no Pst or Plt values, as this requires at least 10 minutes.

Test File:	**F-20210517_ 034**
EUT:	**HFC-III & HFC-II**
Test Standard:	**Test per IEC 61000-3-11 Ed. 2.0 2017**
Test Class:	**Flicker Test, All Parameters**
Test Result:	PASS
Test Date:	**8/10/2020**
Start Time:	**2:34:26**
Stop Time:	**2:37:37**
Test Duration (min):	**8**

Source Qualification:	**Compliance with IEC61000-3-11**
Customer:	
Test By:	
Comments	

Phase A

Vrms (Volts):	231.85	Frequency (Hz):	50.00
I_rms (Amps):	0.283	Power (W):	-1.9
V-THD (%):	0.174	T-Max (ms):	0 (500)
dmax (%):	-0.237 (4.000)	Hi dmax (%):	-0.237 (4.000)
dc (%):	0.000 (3.300)	Hi dc (%):	0.000 (3.300)
Pst (Inst) :	0.449 (1.000)		
Plt :	0.302 (0.650)		

Phase B

Vrms (Volts):	229.84	Frequency (Hz):	50.00
I_rms (Amps):	0.073	Power (W):	-1.4
V-THD (%):	0.151	T-Max (ms):	0 (500)
dmax (%):	0.000 (4.000)	Hi dmax (%):	0.000 (4.000)
dc (%):	0.000 (3.300)	Hi dc (%):	0.000 (3.300)
Pst (Inst) :	0.160 (1.000)		
Plt :	0.159 (0.650)		

Phase C

Vrms (Volts):	227.28	Frequency (Hz):	50.00
I_rms (Amps):	10.728	Power (W):	2118.6
V-THD (%):	0.480	T-Max (ms):	0 (500)
dmax (%):	0.597 (4.000)	Hi dmax (%):	0.594 (4.000)
dc (%):	-0.405 (3.300)	Hi dc (%):	-0.405 (3.300)
Pst (Inst) :	0.907 (1.000)		
Plt :	0.056 (0.650)		

IEC 61000-3-3/11 test report with the Pst and Plt graphs (using Z-ref)

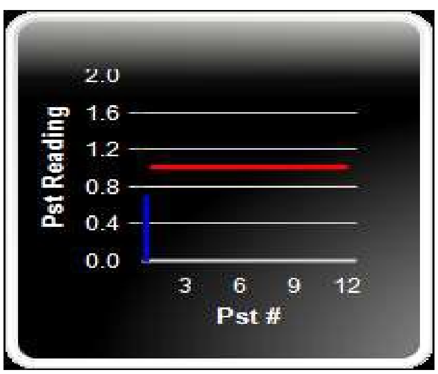
Test File:	**F-20210518_ 026**
EUT:	**HFC-III & HFC-II**
Test Standard:	**Test per IEC 61000-3-11 Ed. 2.0 2017**
Test Class:	**Flicker Test, All Parameters**
Test Result:	PASS
Test Date:	**8/10/2020**
Start Time:	**1:25:49**
Stop Time:	**1:36:01**
Test Duration (min):	**10**

Source Qualification:	**Compliance with IEC61000-3-11**
Customer:	
Test By:	
Comments:	

Phase A

Vrms (Volts):	**228.77**	**Frequency (Hz):**	**50.00**
I_rms (Amps):	**10.228**	**Power (W):**	**1197.6**
V-THD (%):	**0.427**	**T-Max (ms):**	**0 (500)**
dmax (%):	**0.624 (4.000)**	**Hi dmax (%):**	**-0.729 (4.000)**
dc (%):	**-0.621 (3.300)**	**Hi dc (%):**	**0.738 (3.300)**
Pst-1 :	**0.690 (1.000)**		
Plt :	**0.302 (0.650)**		

Pst Spectrum



Plt Spectrum

Phase B

Vrms (Volts):	230.50	Frequency (Hz):	50.00
I_rms (Amps):	0.082	Power (W):	-1.3
V-THD (%):	0.146	T-Max (ms):	0 (500)
dmax (%):	-0.340 (4.000)	Hi dmax (%):	-0.433 (4.000)
dc (%):	0.326 (3.300)	Hi dc (%):	-0.424 (3.300)
Pst-1 :	0.362 (1.000)		
Plt :	0.159 (0.650)		

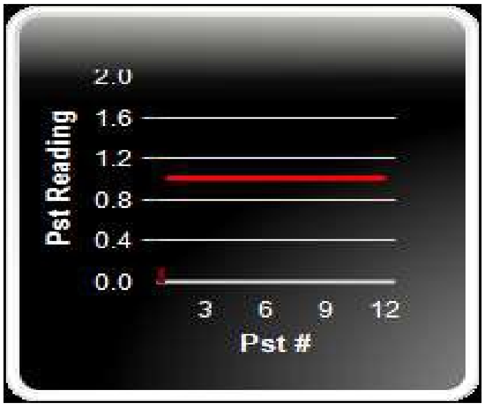
Pst Spectrum

Plt Spectrum

Phase C

Vrms (Volts):	**229.35**	**Frequency (Hz):**	**50.00**
I_rms (Amps):	**0.069**	**Power (W):**	**0.8**
V-THD (%):	**0.157**	**T-Max (ms):**	**0 (500)**
dmax (%):	**0.000 (4.000)**	**Hi dmax (%):**	**0.000 (4.000)**
dc (%):	**0.000 (3.300)**	**Hi dc (%):**	**0.000 (3.300)**
Pst-1 :	**0.128 (1.000)**		
Plt :	**0.056 (0.650)**		

Pst Spectrum



Plt Spectrum

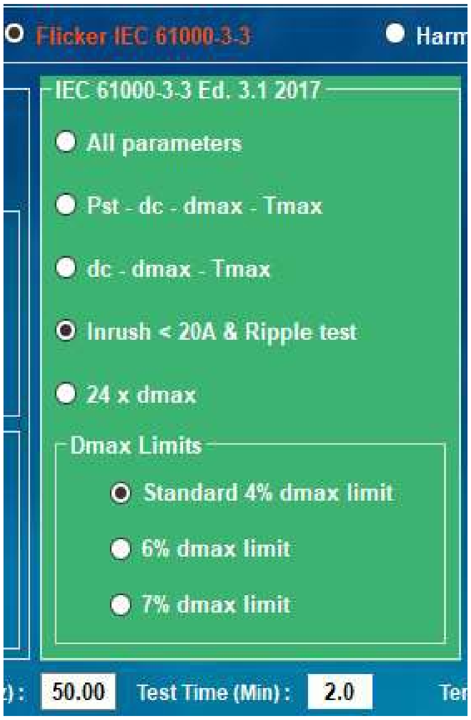
The 24 x dmax report

Test File:	F-20190916_ 973		
EUT:	HFC-III		
Test Standard:	Test per IEC 61000-3-3 Ed. 3, 2017		
Test Class:	Flicker Test, 24 x dmax (Calc. By Current Method)		
Test Result:	PASS		
Test Date:	9/16/2019		
Start Time:	12:56:36		
Test Duration (min):	10		
Source Qualification:	Compliance with IEC61000-3		
3Customer:	Mathieu		
Test By:	24 x dmax test		
Comments:			
Vrms (Volts):	229.85	Frequency (Hz):	50.00
I_rms (Amps):	6.155	Power (W):	2490.7
V-THD (%):	0.298	T-Max (ms):	0 (500)
dmax (%):	-0.969 (6.000)	Hi dmax (%):	-1.043 (6.000)
dc (%):	-0.975 (3.300)	Hi dc (%):	1.068 (3.300)
Average of 22 dmax :	0.966		
Lowest of dmax :	0.878		
Highest of dmax :	1.040		

Test Number:	24 dmax readings:	
1	0.968	
2	0.965	
3	0.883	
4	1.037	
5	1.029	
6	0.882	
7	0.958	
8	0.958	
9	0.953	
10	0.878	Disregarded lowest dmax
11	0.951	
12	0.966	
13	0.958	
14	0.961	
15	0.961	
16	0.888	
17	0.959	
18	0.962	
19	1.037	
20	0.961	
21	1.038	
22	0.957	
23	1.040	Disregarded highest dmax
24	1.029	

The Inrush < 20 A-rms and Ripple Test

This page and the next illustrate the test report for a <20 A & ripple test.



Generally, this test requires just a couple minutes. The user selects the test time (2 minutes in this example). The tests start, and the system does a 10 second pre-test. As soon as the pretest is complete, the user must turn on the EUT, so that the inrush current can be measured.

After 20 seconds, the system will evaluate the current variation (ripple test) to verify whether the ripple is < 1.5 A rms, or more than 1.5 A rms. Provided the inrush is < 20 A rms, the 'dmax" cannot be more than 3.5 %. Also, a 1.5 A rms ripple will not cause more than 0.26 % voltage modulation. Even at the most sensitive point on the Flicker curve, a voltage modulation of 0.276 % is needed to produce a Pst level of 1.00. So, if the product meets both test criteria, it is guaranteed to pass a long Flicker test.

The user may want to repeat the simplified Inrush & Ripple test a few times, to make sure that the maximum inrush current is captured. Given the short test duration, this method still has advantages over a lengthy (up to 2 hours) complete Flicker test.

Below is the test report for a unit that "Passes" the simplified test, and the next page shows a report for a unit that fails the test

Note: Generally, the < 20 Amp and ripple of < 1.5 Amp does not apply to IEC 61000-3-11, as the current will often exceed 20 A – rms.

Test File:	**F-20200509_ 1821**
EUT:	**INRUSH & Ripple**
Test Standard:	**Test per IEC 61000-3-3 Ed. 3.1 2017**
Test Class:	**Flicker Test, Inrush < 20A & Ripple test (Calc. By Current method)**
Test Result:	EUT meets IEC 61000-3-3 per Clause 6.1
Test Date:	**5/2/2020**
Start Time:	**2:21:02**
Stop Time:	**2:23:12**
Test Duration (min):	**2**

Source Qualification:	**Compliance with IEC61000-3**
3Customer:	**RIPPLE**
Test By:	
Comments:	

Phase A

Vrms (Volts):	**229.83**	**Frequency (Hz):**	**50.00**
I_rms (Amps):	**8.447**	**Power (W):**	**1273.2**
V-THD (%):	**0.247**	**T-Max (ms):**	**0 (500)**
dmax (%):	**-0.983 (4.000)**	**Hi dmax (%):**	**1.039 (4.000)**
I-Variation (A):	**-0.076 (1.5A)**	**I_rms-peak (A):**	**8.447 (20.0A)**

==

The Inrush < 20 A-rms and Ripple test report (fail)

Below is the test report for a product that fails the simplified "Inrush & Ripple" test, because the current variation exceeds the maximum permitted 1.5 A rms ripple.

Test File:	**F-20200509_ 1822**
EUT:	**INRUSH & Ripple**
Test Standard:	**Test per IEC 61000-3-3 Ed. 3.1 2017**
Test Class:	**Flicker Test, Inrush < 20A & Ripple test (Calc. By Current Method)**
Test Result:	EUT fails simplified inrush-ripple current test
Test Date:	**5/2/2020**
Start Time:	**2:21:15**
Stop Time:	**2:23:27**
Test Duration (min):	**2**

Source Qualification:	**Compliance with IEC61000-3**
3Customer:	**Inrush & Ripple test**
Test By:	
Comments:	

Phase A

Vrms (Volts):	**229.83**	**Frequency (Hz):**	**50.00**
I_rms (Amps):	**5.696**	**Power (W):**	**1263.5**
V-THD (%):	**0.255**	**T-Max (ms):**	**0 (500)**
dmax (%):	**0.553 (4.000)**	**Hi dmax (%):**	**-1.093 (4.000)**
I-Variation (A):	2.81 (1.5A)	**I_rms-peak (A):**	5.70 (20.0A)

==

Storing, Replaying & Analyzing data files

The system stores data in either in ASCII format or “zipped” format. When a test is completed, the data file is either in ASCII or is converted to “zipped” format, in order to preserve disk space. The HFa-3-75 functions as a data logger, so the ASCII files can be very big. For example, the harmonics and flicker test file in ASCII format can be several hundred Mega-bytes. Hard disks are 1 Tera-Byte or 2 TB, or even 4 TB nowadays, i.e. can store at least 1000 files of 1 Giga-byte each. The “zipped” format compresses the test data by about a factor 5. Hence the typical hard drive of 1 TB can handle thousands of data files. Even a laptop PC with a 500 Giga-byte hard drive can store hundreds if not thousands of test files this way.

When the system is closed, and “zipped” data is selected, it automatically deletes the large ASCII files, but keeps the zipped versions. The user can replay either ASCII or zipped files. The ZippedData as well as the RawData sub-directory are found under the C:\CNS\HFa-3-75 directory.

The “zipping” process can take a minute or so, so sometimes Windows-10 will show a “not responding” message. In that case, just be patient and wait for the “zipping” to complete.

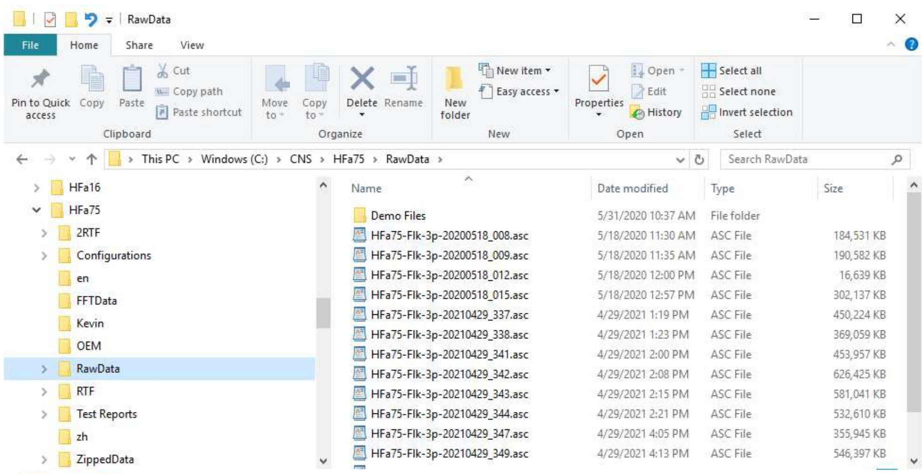


***Figure 39** The Raw Data directory*

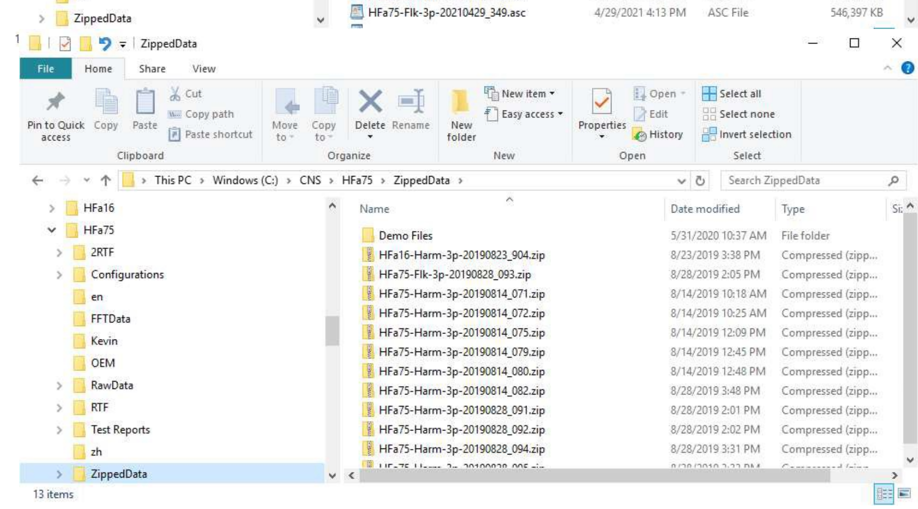


***Figure 40** The Zipped Data directory*

To replay a file, click on “File” and then “Replay Test”, and then select the file to be replayed.

Note that you can select either a Zipped File” or an ASCII file (see Figure 39 & 40)

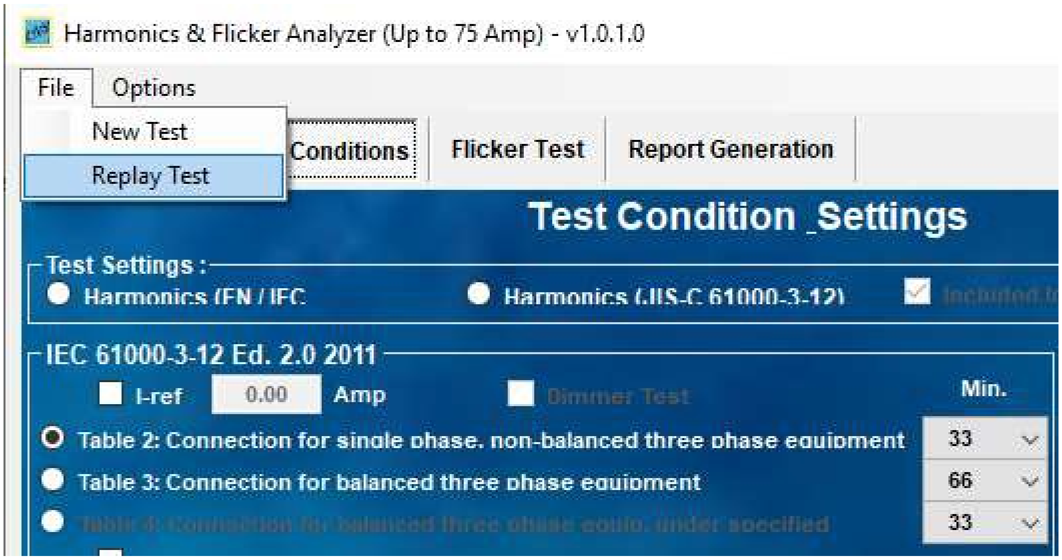
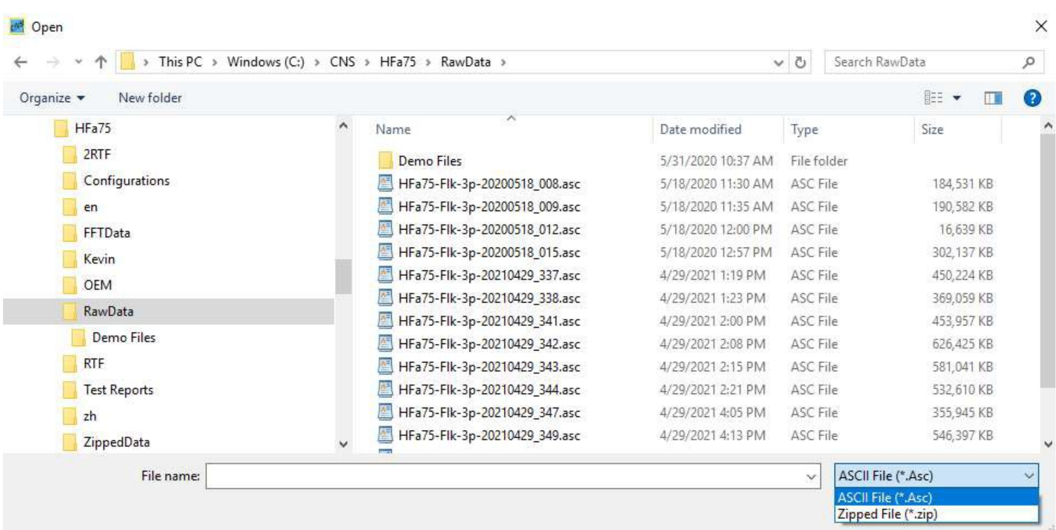


Figure 41 *Selecting to replay a file, and either select a Zippedor an ASCII file type.*

The replay mode is very powerful, as it allows the user to look at unfiltered data for any 200 ms measurement window.

Note that the user can step one 200 ms window forward or back, or ten windows.

Replay mode runs about twice as fast as an actual measurement. So, a 10 minute Flicker test will replay in 5 minutes, and so will a 10 minute harmonics test. The human eye can follow about 2 readings per second, so the "double speed" is about the optimum approach.



This analysis capability is also beneficial when lookingat transient behavior occurring during a Flicker test.

Figure 42 100 half cycles display

The instant during a Flicker test when a resistive load is turned “on”

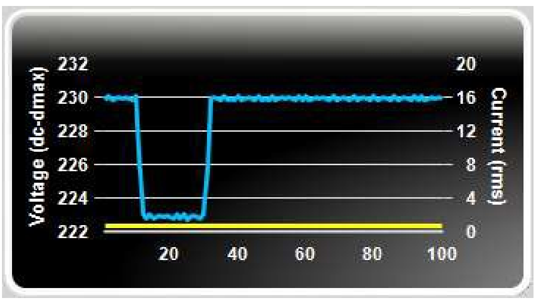


Figure 43 *180 ms voltage drop-out*

This copy of the graph shows the instant during a Flicker test when a voltage dip with a duration of 180 ms occurs.

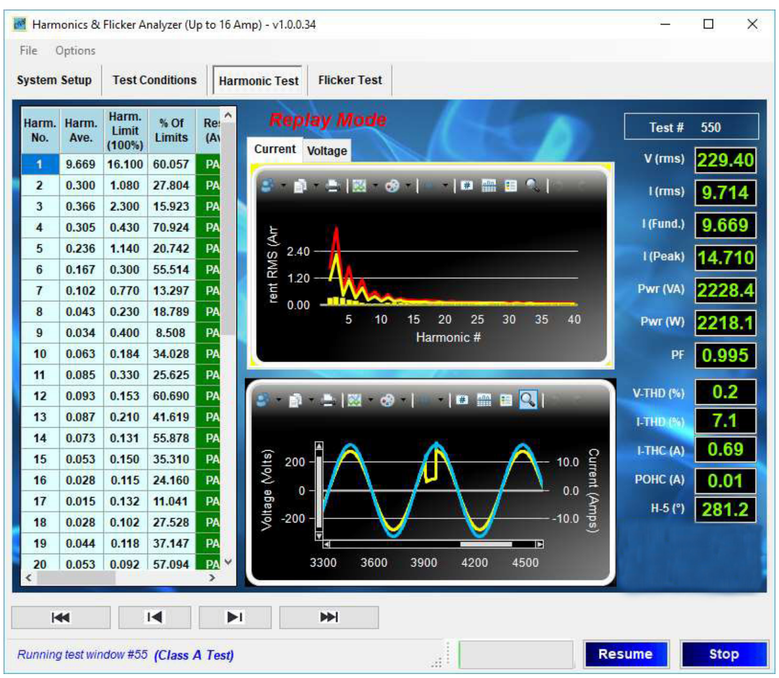


Figure 44 *Short glitch*

The instant where a brief glitch in the EUTcurrent occurs (bottom graph – zoomed).

Some advanced user defined options

Selecting the IEC 61000-3-11/12 standards revisions for testing

There are some applications where the user may want to test to IEC 61000-3-12 Edition 1, instead of the presently valid edition 2.0 of the standard.

Edition 2 has a more elaborate set of test conditions, but all measurements and limits are the same, and follow IEC 61000-3-3.

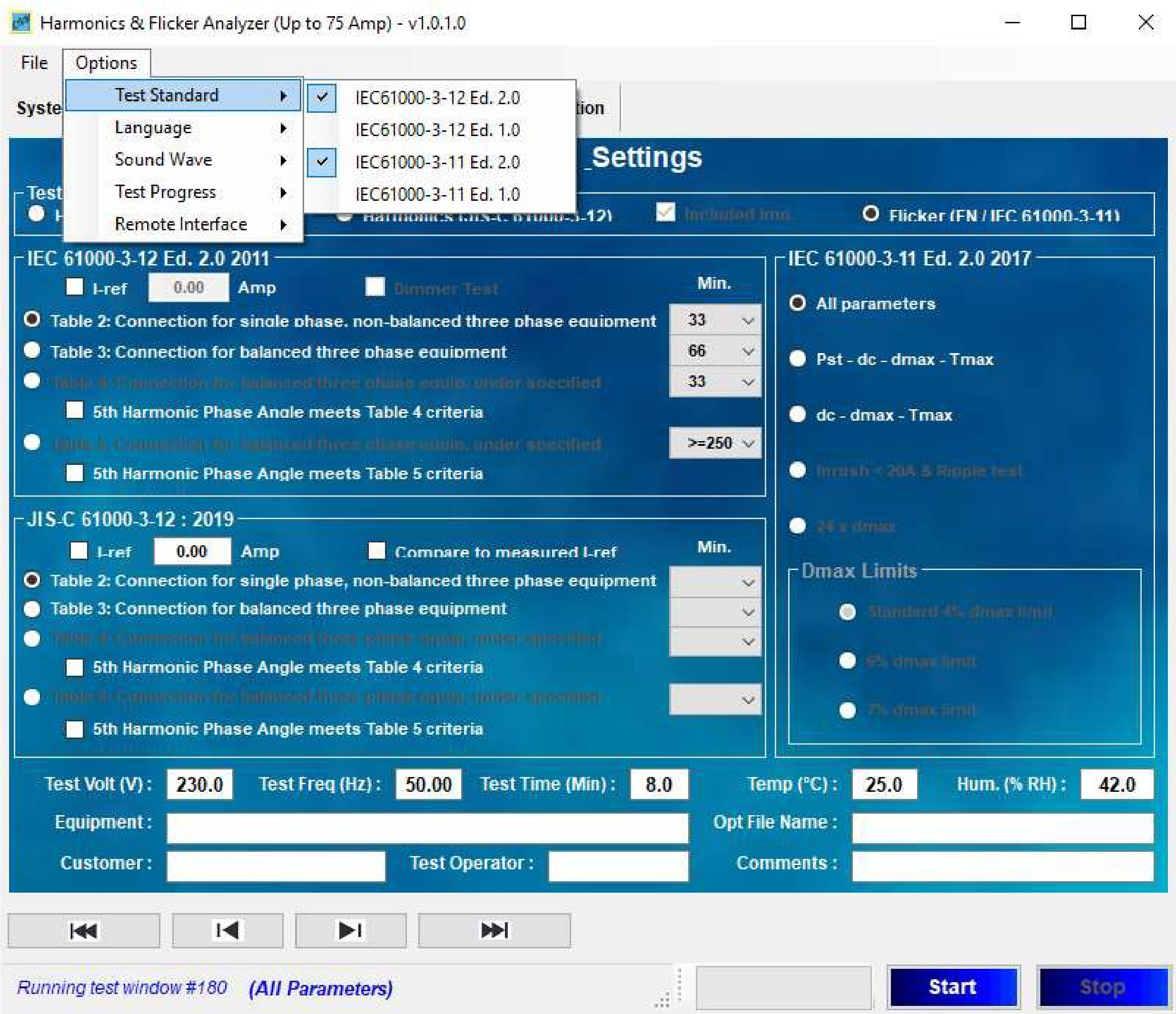


Figure 45 *test settings for the various IEC 61000-3-11/12 editions*

Customizing the test report

There are several settings that the user can change to be specific for his/her application.

In the C:\CNS\HFa-3-75\Test Reports\RTF\Templates\ is a Report Template file in “xml” format. The user can enter a name and other info that will appear as header is the test reports.

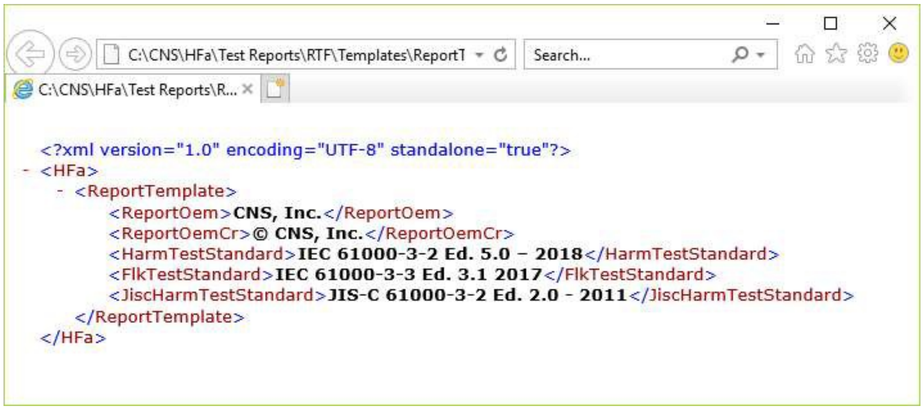
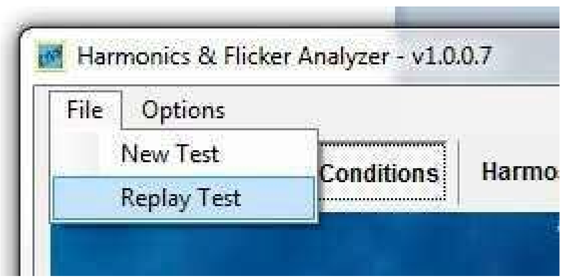


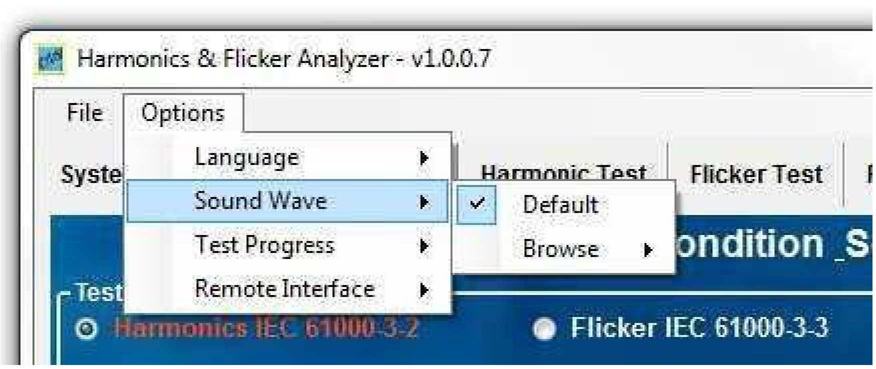
Figure 46 *The report header template file*

Selecting a file for replay



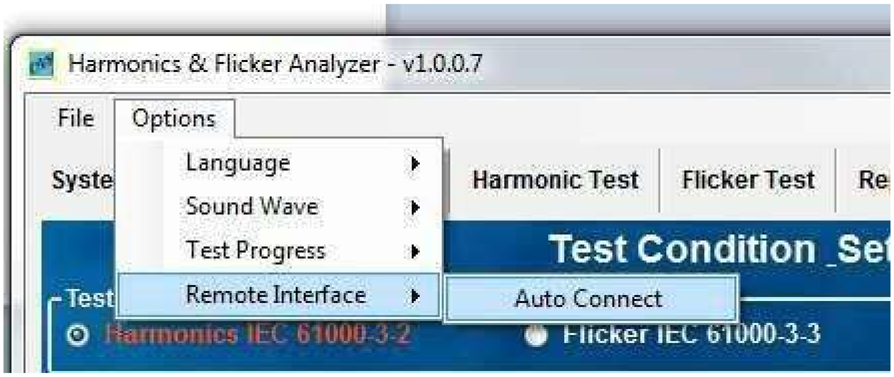
The user can select one of the demo files (used to generate this manual) and replay those files. These can be either “asc” files or “zip” files.

Selecting the sound file to play for PASS and FAIL conditions



The system has a couple default sound files that it will play when a test is finished.The user can change those files to play a specific tune.

Configuring the power source connection



The user can select “Autoconnect” which means that the software will “look” for the same PC interface thatwas defined earlier.

The alternate is to configure the interface when the system is turned “on” with the ability to select either serial, or GPIB connections as applicable to the selected power source.

Figure 47 *The HFA-3-36 – 19" form factor with built-in Reference impedance*

Specifications for HFa-3-75 & HFa-3-36

Electrical

Frequency range of fundamental line component; 45 – 65 Hz

Sampling method; PLL based with 512 samples/cycle (simultaneous per channel), or fixed frequency sampling

Harmonic analysis range; up to harmonic order 200 (10/12 kHz)

Harmonic spectrum display up to harmonic 40, can optionally be selected to show 2 to 9 kHz

Voltage input range; 0 – 350 V-rms, ± 500 Volt peak std, 500 V-rms ± 700 V-peak optional.

Voltage measurement accuracy; 0.1 % + 10 mV, Voltage harmonics; 0.1 % + 0.1 % per 100 Hz + 5 mV

Current input range; 0 – 36 A-rms, 0- 100 A-pk for 10 seconds, 0 -100 A peak for HFa-3-7575.

Current measurement accuracy; 0.1 % + 5 mA in Phase-A, harmonics accuracy: 0.1 % + 0.02 %/100 Hz+5 mA

Power Factor range & accuracy; -1.000 – 0 - +1.000, +/- 0.003,

Power measurement: 1 – 15000 VA / 1 – 15000 Watt, per phase, measurement accuracy; 0.15% + 0.1 Watt

Phase measurement range; 0 – 360 °, Phase accuracy 50 – 2500 Hz; 0.5° + 0.2° per 100 Hz

EUT interface Standard version IEC plug for HFA-3-75-3S, Schuko and universal plug for HFA-3-75-3-19, plug-sleeve up to 40 A-rms or optional 75 A-rms for HFa-3-7575. Rear terminal block for up to 80 A-rms – 150 A-peak / phase

Optional IEC 60725 Reference Impedance or Z-test can be built-in (must be ordered separately).

Mechanical, input power & interface

Upgraded 19” rack version;16” x 3.5” x 22” (W x H x D). System comes with rack ears.

Weight; < 20 Lb (9 Kg) without optional Reference Impedance, 40 lb (18 Kg) with Reference Impedance (HFa-3-36)

19” Rack with HFa-3-75 and Z-ref and Z-test , 40” high, weight 155 Lb. (70 Kg)

Input power; 100 – 240 Vac 50/60 Hz, max 100 Watt (120 Watt for models with built-in Reference Impedance)

PC interface; USB-2 or USB-3 compatible port, suitable for Windows-7-8-10.

Software:

Fully compliant with latest editions of IEC 61000-3-11, IEC 61000-3-12, and measurement standards IEC 61000-4-7, IEC 61000-4-15. System can control power sources from most manufacturers.

Typical hardware connections (2) Pacific Power©

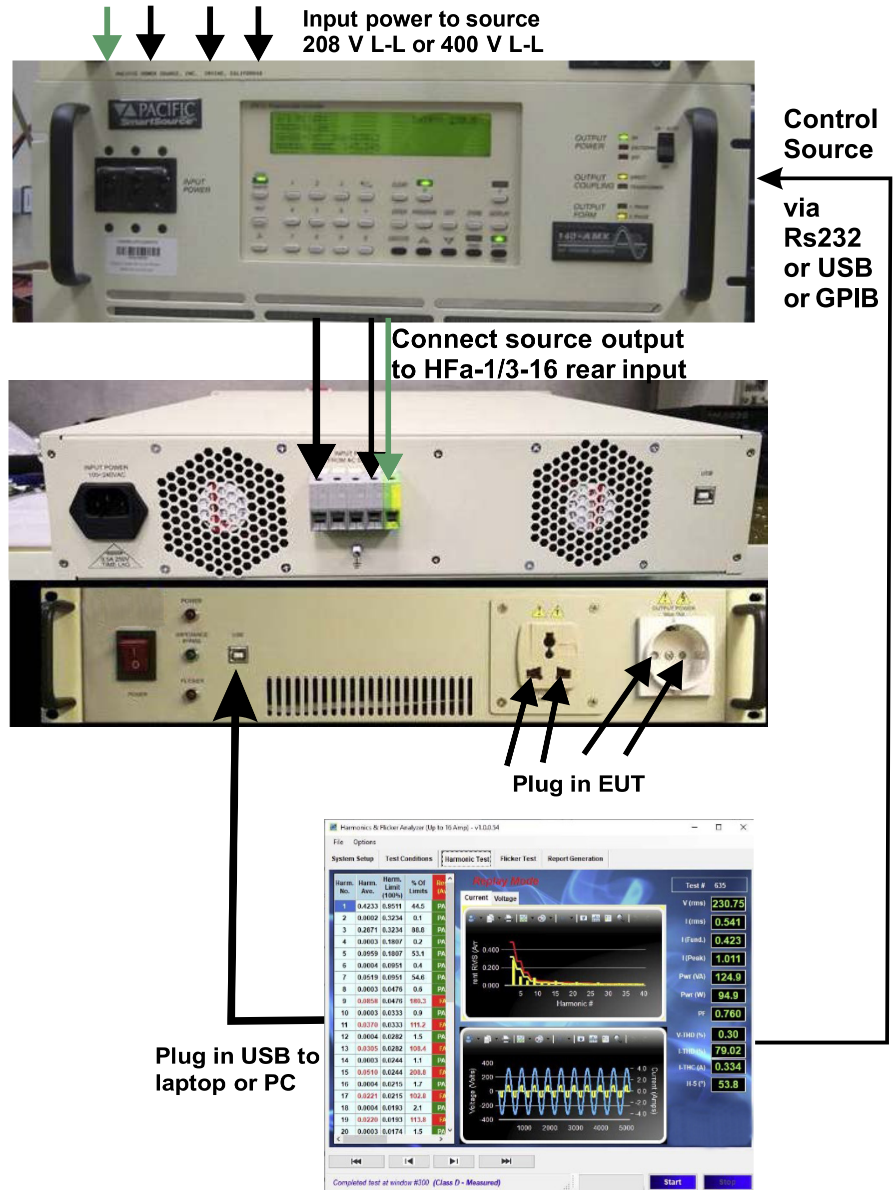
Provide input power to the power source,usually 3 phase 208 V L-L in the US, and380 – 440 V L-L in many international markets.

Connect the source output voltage to theHFa-3-75-16 input. This can be single phase (Line-neutral and GND) or 3 phase for the HFa-3-75-3-16/40/75 (single phase shown)

Plug the equipment under test into the frontoutlet socket

Connect the USB connector of the HFa-3-75 to the laptop or PC USB port.

Connect the PC or laptop to the Power source via RS232 (COM port)GPIB, or USB depending on power Source type.



Typical hardware connections (3) Ametek©/Teseq©

Input power to source 208 V L-L or 400 V L-L

Provide input power to the power
phase 208 V L-l in the US, and 380 –
European and other international

source, usually 3
440 V L-L in many
markets.

Connect the source output voltage
Neutral-GND) to the CCN1000 (or
or the HFa-3-75 input terminals in the
the chassis.

(Line-
PACS)
back of

Connect source output

to

CCN1000 / PACS input terminal blockin the back

This can be single phase (Line-neutral

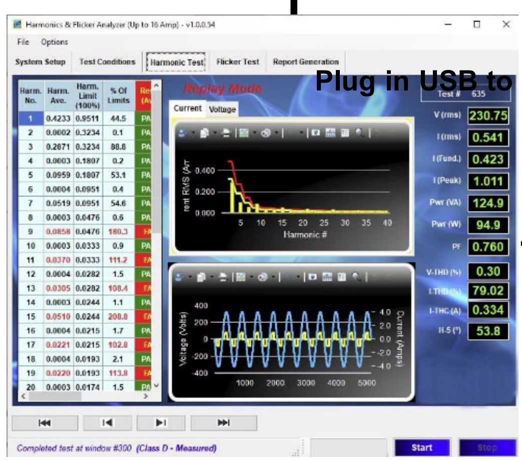
and

GND) or 3 phase for the HFa-3-75-3-
HFa-3-75-3-75 (single phase shown)

16 and

Plug the equipment under test into the
USB outlet socket (CCN1000 or
PACSupgraded to HFa-3-75 – USB
ifc.

front



Plug in USB to laptop or PC

Connect the HFa-3-75 - USB to the
or PC USB port. If power source control
desired, connect the PC or laptop to the
source.

laptop
is
power

Connect from COM portto NSG100-7 or 5001iX
or use USB-to-RS232 cable if PC or laptop does not have COM port