BOURBAKY

Electronic **M**easurement **A**utomation

Product Note

Advanced Test Tool for Digital to Analog Converter

Today components used in wireless or video applications require specialized test equipment from bench, fine characterisation for 10 to 14 bits converters with hundreds of Megahertz sampling frequency is an heavy task for lab engineers.

Design verification needs are complementary to simulation tools for designers, but close to lab know-how and measurement trip and tricks. Shorter conception to production cycle asks to speed up each path in the process. Accuracy, repeatability and traceability must be present at each measurement test procedure, much more complete verification information should be quickly and easily available in order to enable efficient design work.

This tool is build by Bourbaky using **EMA** software architecture. High end bench Agilent equipments, enables highly accurate verification. It combines highly efficient equipment control “as lab bench” with simple usage “as toast burner”, it brings a compact and efficient way to keep verification results, as well as enabling data export to complementary analysis and/or presentation tools.

Designed with selected equipments, it adds the ability to complete existing connected simulation and test solution for the **A**dvanced **D**esign **S**ystem. Complex real world digital modulation and resulting -real- output signal may be measured and then used in complete systems simulation in **ADS** from Agilent Technologies.

C² LAB CMG CENTRAL LAB

This Advanced Test Tool was designed in collaboration between ST microelectronics & Bourbaky. It is used at ST microelectronics CMG Central Laboratory to get complete characterisation of newly designed DAC.

Agilent Technologies
Channel Partner

Contents

EMA is used for **E**lectronic **M**easurement **A**utomation.
This acronym is used to designate a complete test system that uses the software architecture designed by Bourbaky to build complex and evolutive measurement applications.
EMA is build from :

-a manager sw, also called Organizer, customized to application needs mainly through configuration files and through specific graphical results consulting tools.

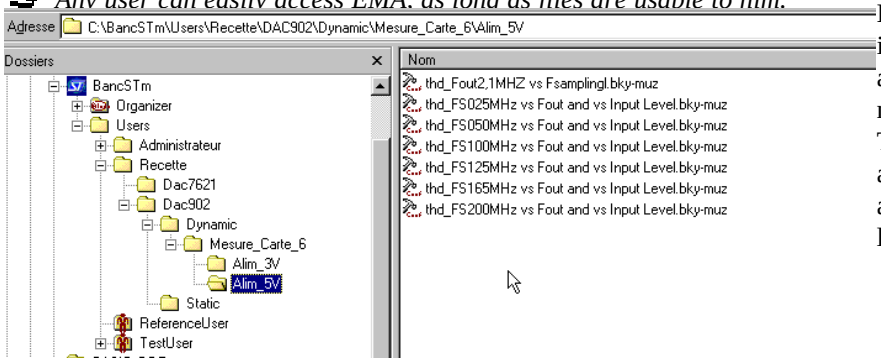
-a T&M collection of applications, also called BKTM, that uses a core standardized module used to dynamically load specific instrument device drivers and measurement procedure.

The "**Advanced Test Tool for DAC**" (ST DAC Bench) is an EMA test system build to Test Digital to Analog Converters used in wireless, video and related products.

1-How to work with

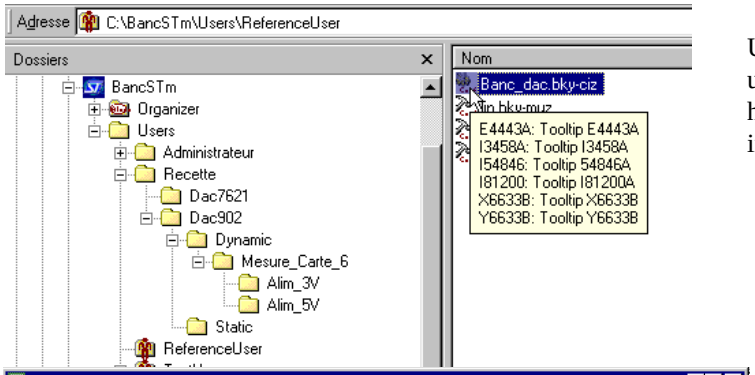
Today users are already knowing standardized tools like MS/Explorer from usual operating systems. When using EMA, you will find measurement procedures and results just with the Explorer, as for any file. The name itself, the location where it is, are totally free -only limits are those from operating system-.

Any user can easily access EMA, as long as files are usable to him.

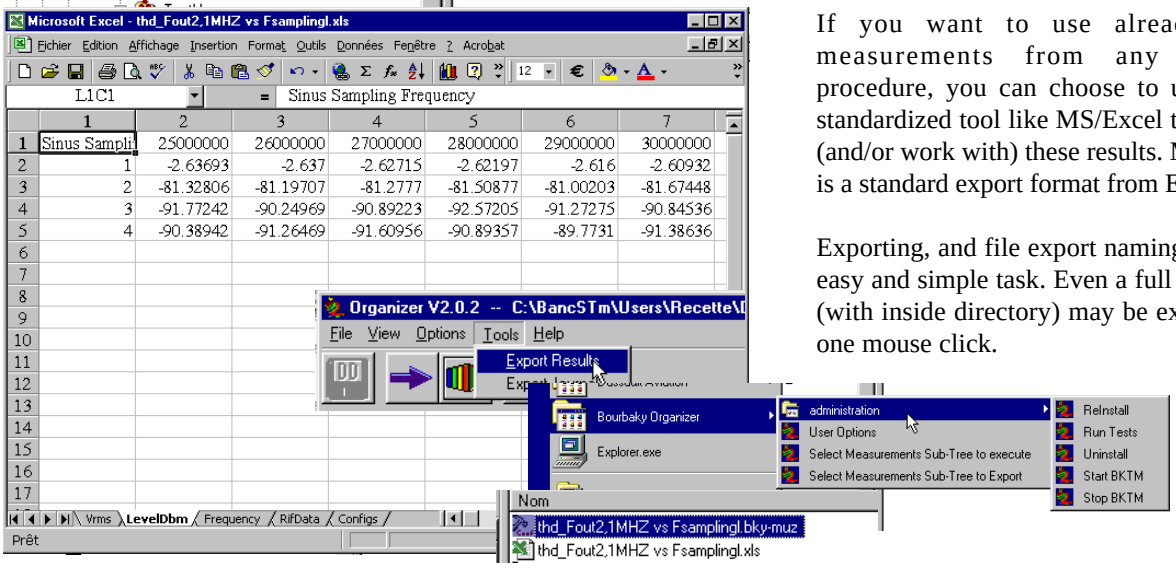


Even if it is the first time you logon, it's easy to understand such files are about Harmonic Distortion (THD) measured on DAC902 at 5 Volts. That was done with Board Test No 6, and results are for different sampling and signal frequency, versus input level.

As, according to your current user rights, you may be able to copy such results elsewhere, it means you will be able to construct your own directory dedicated to the DUT you have to check. That's simple, easy and efficient : whatever you can do with files from the Explorer is usable with EMA test procedure.



User interface, embedded inside Explorer also uses standardized functionality like ToolTips. It helps user to put and get complementary information effortless.



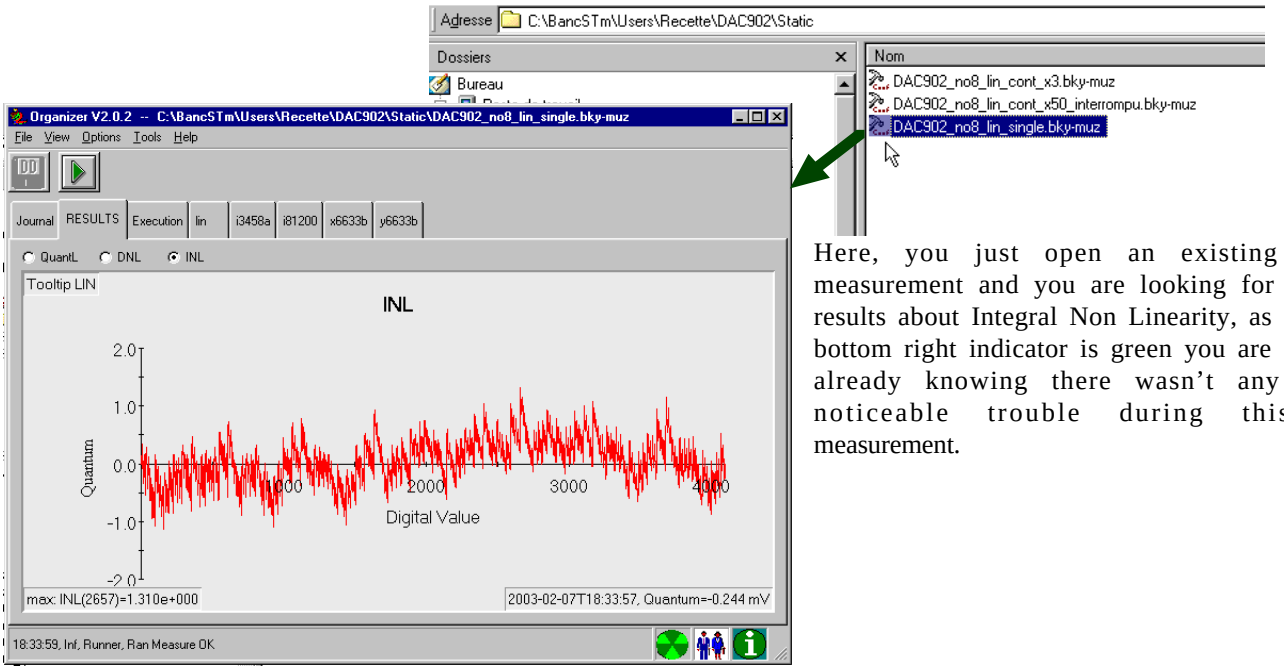
If you want to use already done measurements from any existing procedure, you can choose to use some standardized tool like MS/Excel to display (and/or work with) these results. MS/Excel is a standard export format from EMA :

Exporting, and file export naming are also easy and simple task. Even a full directory (with inside directory) may be exported at one mouse click.

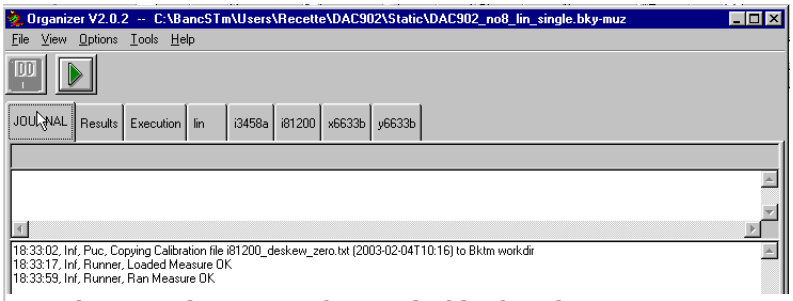
NB : Each procedure file as an EMA object does contain any information needed to enable full traceability regarding stored results. When exported to MS/Excel, aside results data, a large part from all needed complementary information are also exported to different sheet of the same file.

2-Static Measurements

Now, if you are a normal user, able to deal with those files, and simply uses a mouse click to open an EMA procedure file, say a file related to a static linearity measurement, you will get :



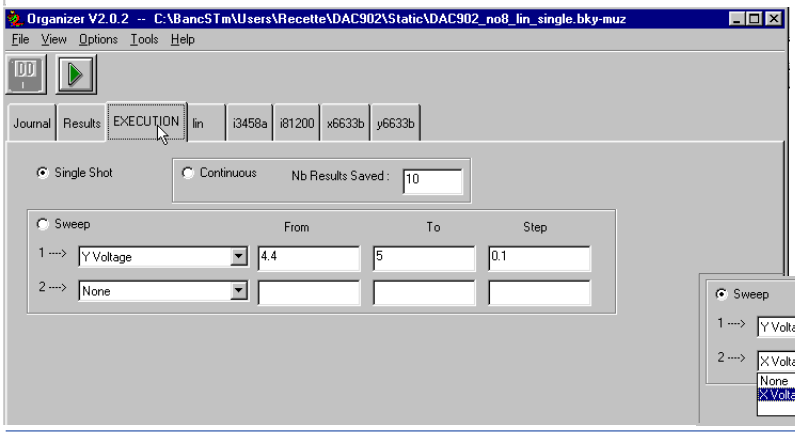
Here, you just open an existing measurement and you are looking for results about Integral Non Linearity, as bottom right indicator is green you are already knowing there wasn't any noticeable trouble during this measurement.



If you want to know more about it you can have a look to Log :

Now you know when the measurement was done, how many time it took, what calibration file (or other useful information) was used, ...

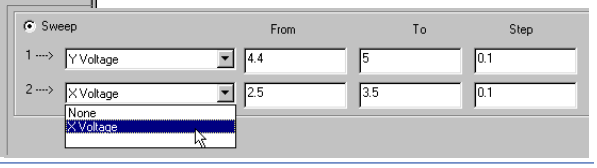
Consulting results is something valuable, but doing new measurements with same -or different -instruments adjustment is the real work EMA is able to execute. You have just to select from "Execution" how you want to launch the measurement :



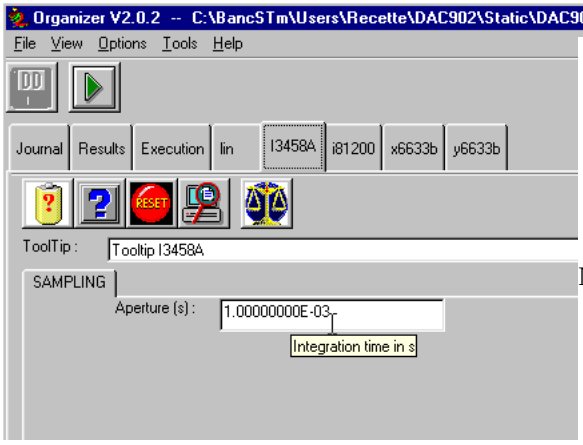
You can select a single shot or continuous execution (useful to have a look on how reproducible is the result).

You can also decide to sweep some parameter to get the result evolution upon the parameter value.

It's possible to combine two parameters as sweepable.



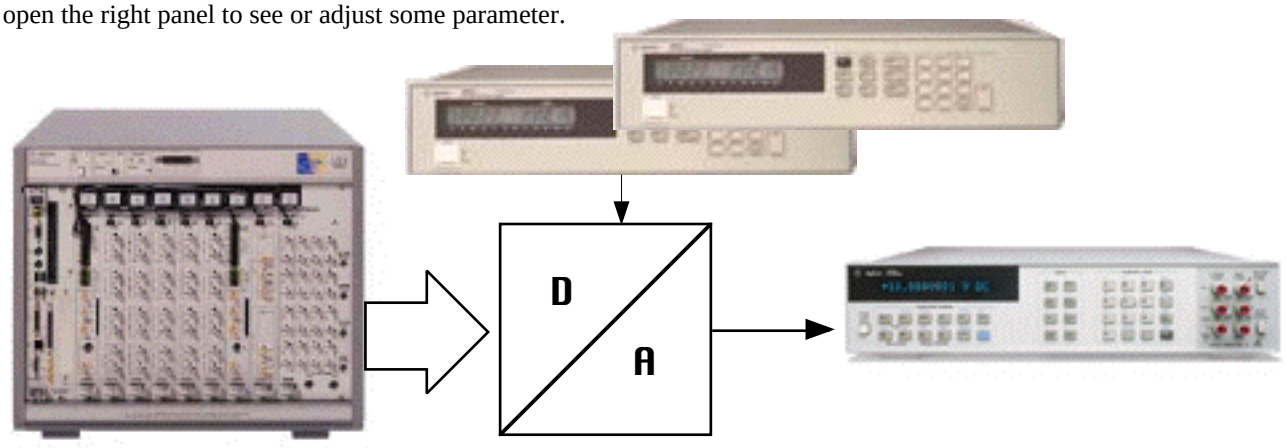
Even if it seems easy to re-execute existing measurement procedure, get new results, brings it to your favourite location after exportation, the real goal for an ATE system is to be able to use equipments as you want. Here for example, we are trying to measure linearity from a DUT using an Agilent 3458A DMM. But what about the allowed integration time for each measured step ?

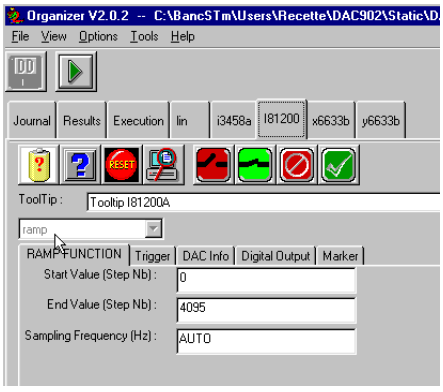


Nothing so easy to know, and to adjust. With EMA sw you have just to choose the 3458A panel, and the current value from the aperture time is displayed.
If you want another one, type in, then restart the measurement with the green arrow ...

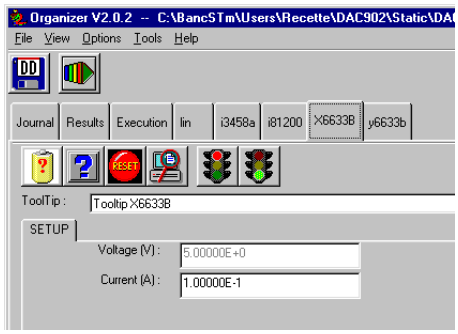
NB : As integrity is taken into account by EMA, as soon as you validate an new adjustment value current results aren't any more displayable (but as long as you didn't overwrite original procedure file, you can still return and have a look "before change").

Of course, the 3458A DMM isn't the only one device used to get static linearity results. There are also a VXI 81200 digital generator, and some precision power supply (6633B). For each device used by this measurement, there is just to open the right panel to see or adjust some parameter.





Depending upon device, there may be less or more parameters available to user for adjustment. If the device is complex enough, there may be more than one panel to access all needed adjustments (in 81200 picture example, there are five different panels).



NB : Not any adjustable parameters are "usable". EMA allows the super user to choose which parameter will be available to normal user. More, depending upon each procedure kind, normal user may access different panels/parameters from each device.

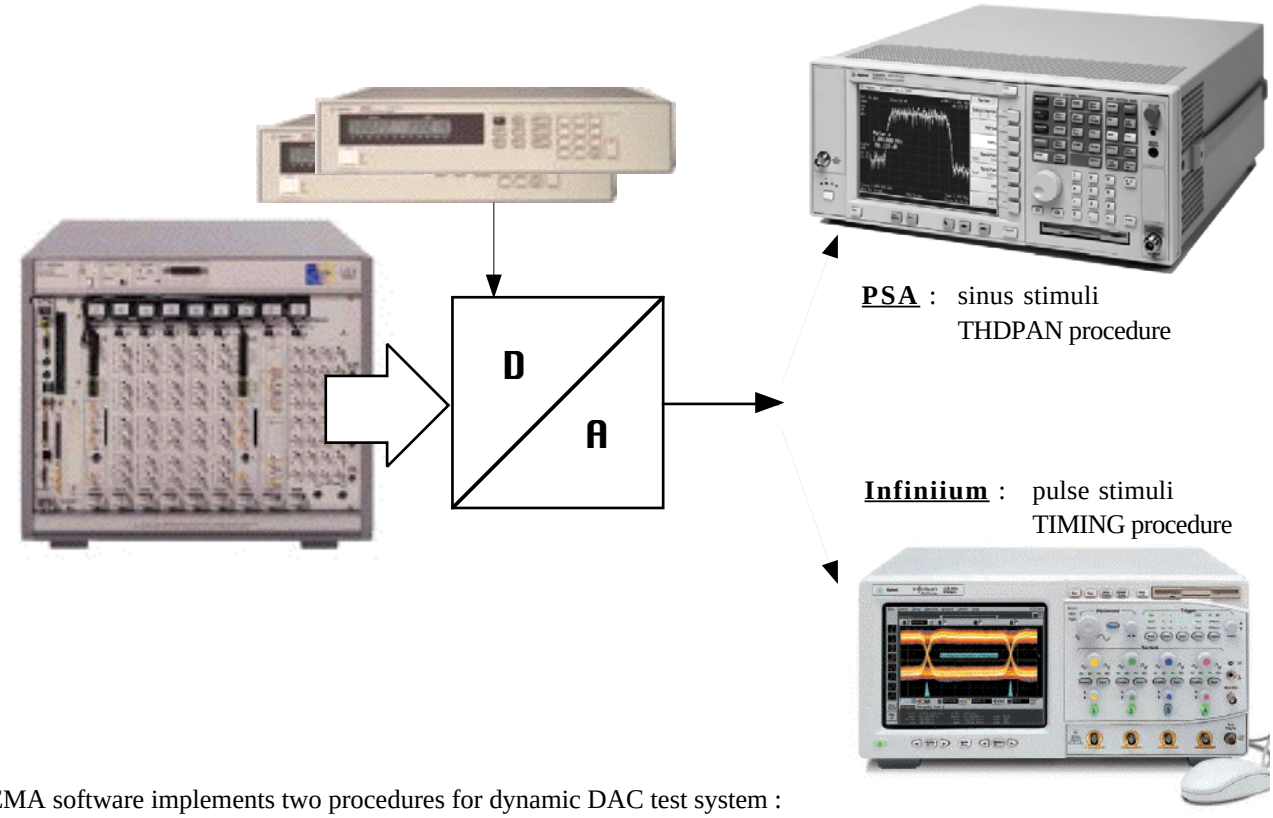
3-Dynamic measurements

Aside static specifications, there are two kind of dynamic measurements, those using sinus stimuli like THD, SFDR, ... and those about step or pulse signal like rising or settling time.

Each one uses same Agilent 81200 VXI digital generator as for static linearity, but different measurement device :

-E4443A **P**erformance **S**pectrum **A**nalyzer for sinus stimuli

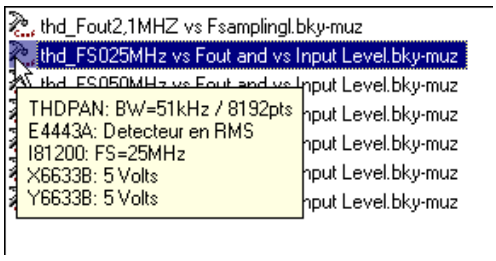
-58846A **Infiniium** oscilloscope for pulse stimuli



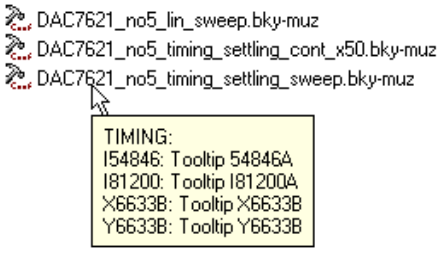
EMA software implements two procedures for dynamic DAC test system :

-one dedicated to PSA analyse device on sinus stimuli, named **THDPAN** (THD for Harmonic Distortion, PAN for Panoramic spectrum).

-one dedicated to Infiniium measurement on pulse stimuli, named **TIMING** (main results are time values)



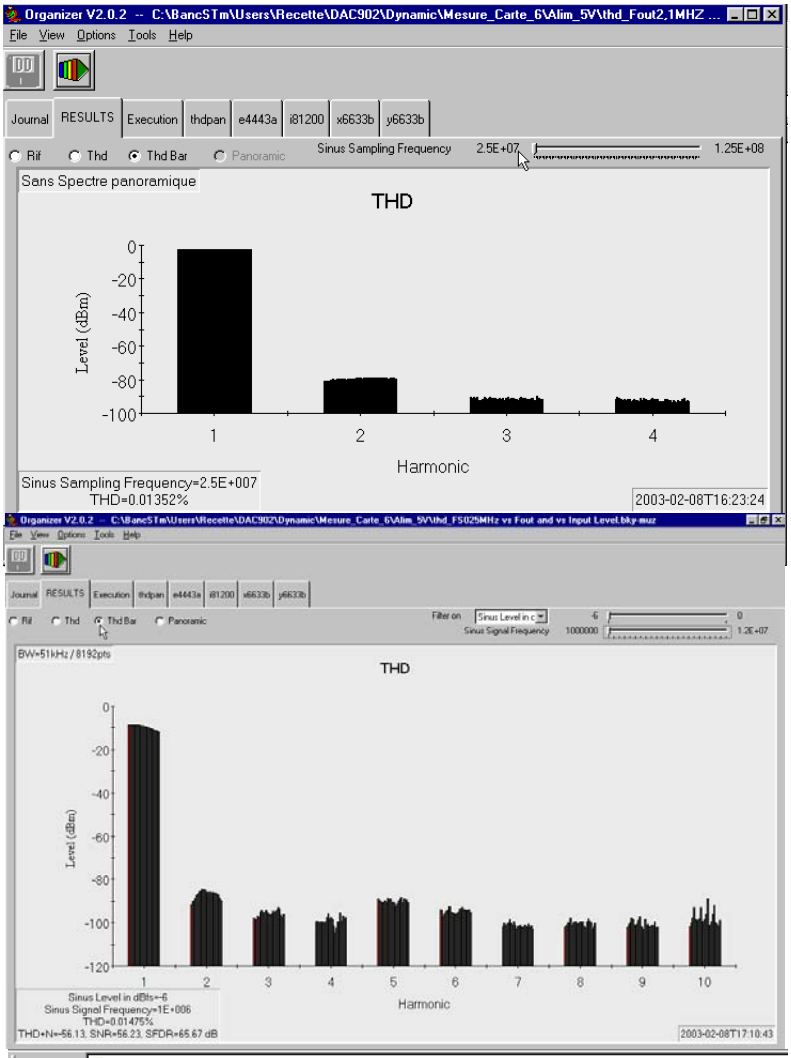
THDPAN EMA file procedure



TIMING EMA file procedure

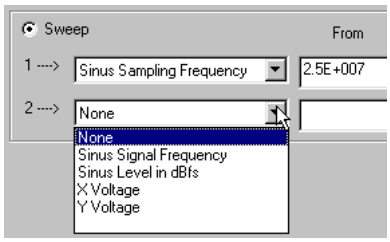
Even if the VXI 81200 Digital Generator is able to be used as well for static as for dynamic measurement procedures, dynamic measurements are demanding more difficult to obtain specifications. Ability to use deskew adjusted to DUT board is one of significative enhancement dedicated to dynamic measurement (at clock sample rates to 670 Mb/s or 2 Gb/s depending upon hw used).

•**THDPAN** Elementary Test Procedure

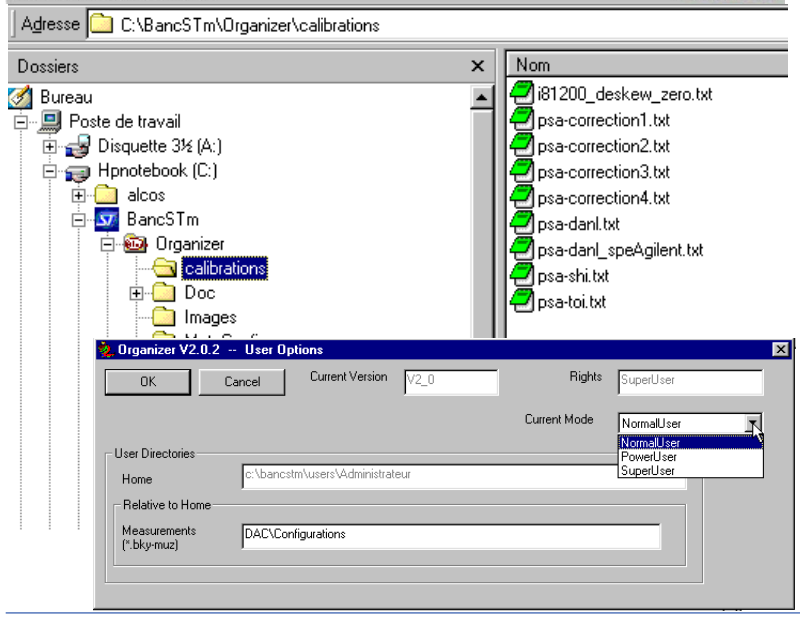


Here is a measurement of Harmonic Distortion, based on harmonics 2, 3 and 4 (number 1 is the fundamental) and showing evolution at a fixed sinus frequency (2.1 MHz) for sampling frequency from 25 to 125 MHz.

As for any EMA procedures, two parameters are sweepable.

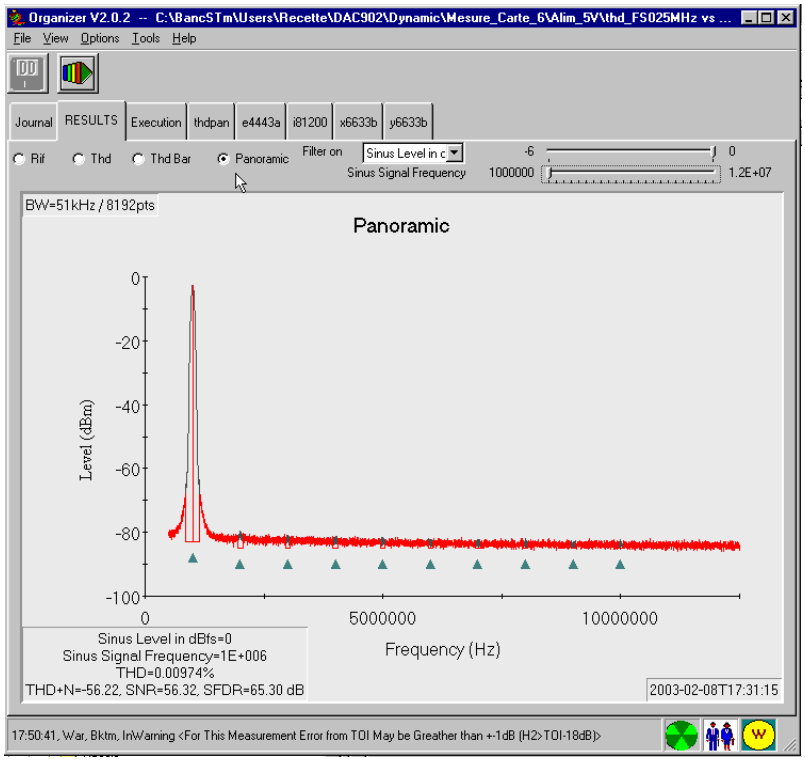


This second example shows a sweep on the two parameters level (-6 to 0 dBfs) and sinus frequency (1 to 12.5 MHz) at a fixed sampling frequency of 25 MHz.



Particularly needed for dynamic measurement, calibration and correction files are used. EMA standard architecture enable usage of such files. These files are usually under EMA “super user” control. However, each result get from EMA indicates file name and the operating system date related.

User Level selection in EMA software.

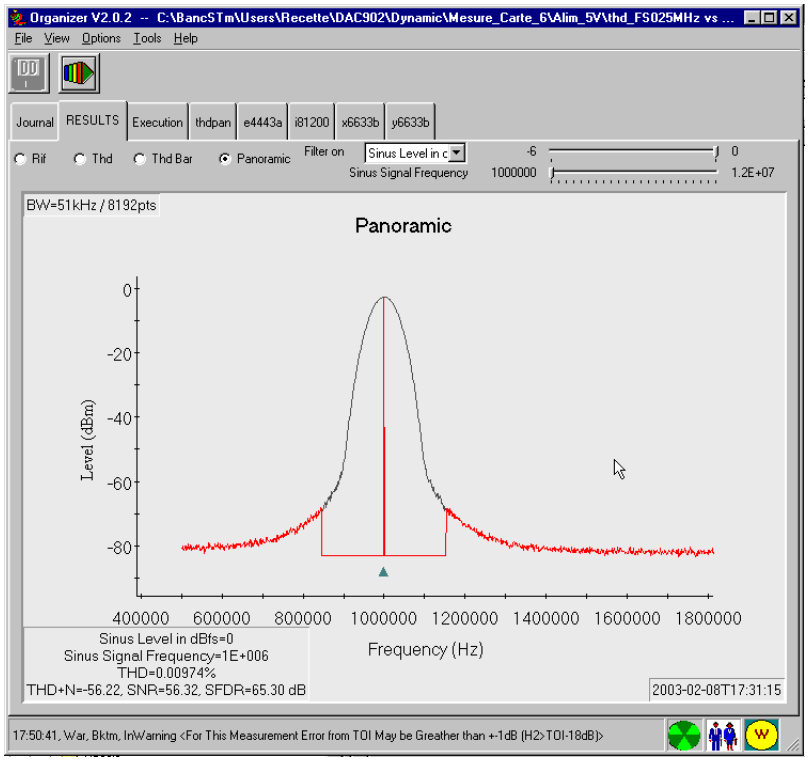


"Panoramic Spectrum" - each mark indicate a calculated harmonic location

THDPAN procedure isn't only able to measure distortion, but also other usual DAC parameters :

- •THD + Noise
- •SNR
- •SFDR

All from these other parameters are extracted form THD measurements and a special spectrum called Panoramic (because numerous points may be used to cover a large span, using a thin bandwidth filtering). This Panoramic spectrum is particularly useful when offline result consulting, at this time the user is able to zoom on a particular point of interest. As there may be thousand of points, such a zoom may be done, without the need for a new measurement.

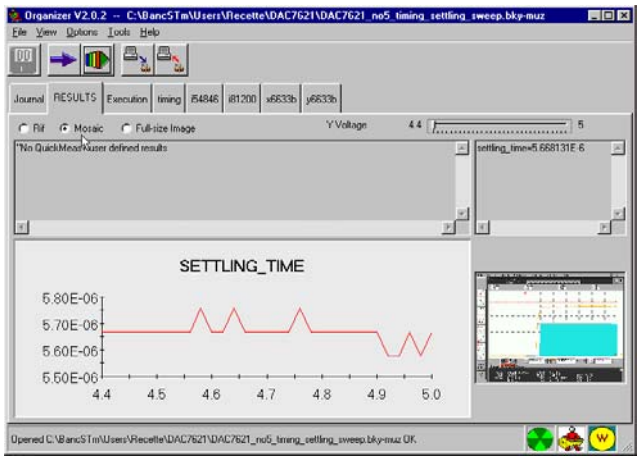


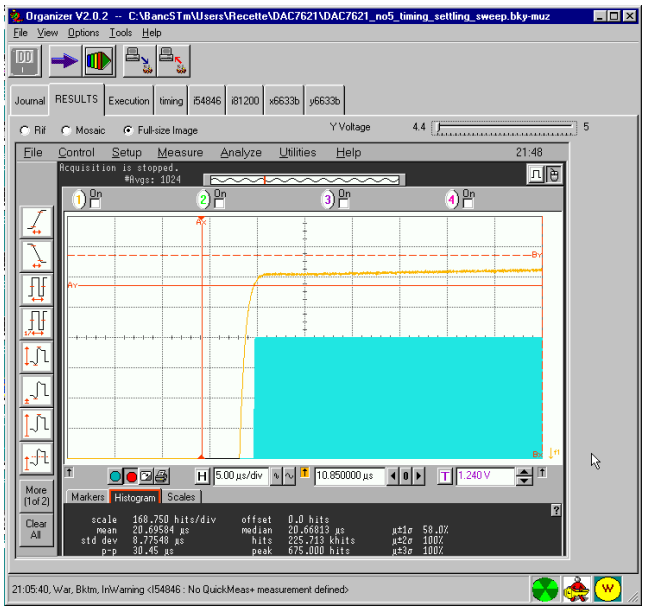
"Panoramic Spectrum" - zoom on the fundamental to show correction

Panoramic spectrum is always a complement to THD measurement. PSA Input attenuation may be automatically adjusted to best suit DUT analog output and instrument current characteristics (SHI, DANL, ...).
Even if BW filtering is thin for large span due to high number of points, the BW used to measure each harmonic for THD is thinner and enable a better level accuracy for each discrete harmonic signal.

Bourbaky has developed a special correction mode, enabling to replace direct spectrum measurement from span mode (here the grey curve) with better level accuracy from discrete harmonics when available (here red curve).
This correction isn't only useful to user for a better display and understanding of measurement, but it enable accurate noise evaluation needed to compute SNR.

•**TIMING** Elementary Test Procedure



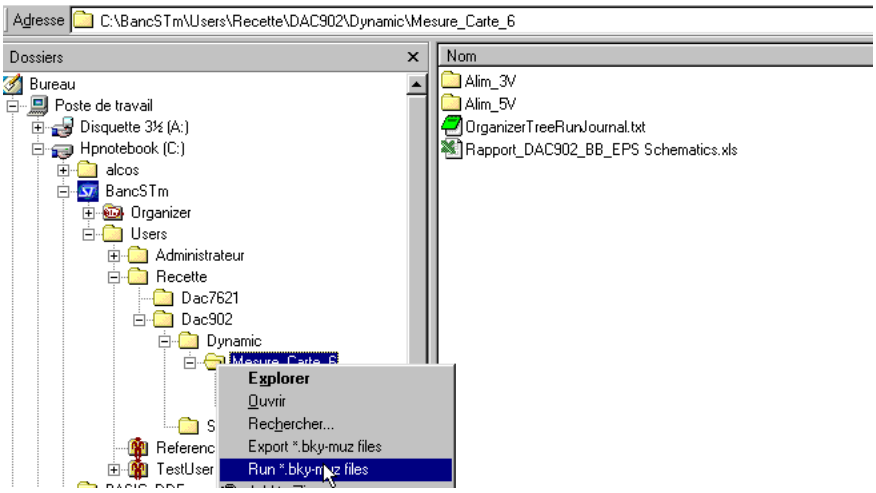


Timing measurements are using infiniium oscilloscope to capture analog signal at DAC output.

Any automatic measurement facility from Agilent infiniium oscilloscope may be used, like rise time, fall time, ...
The Setup Time measurement uses time-level histogram facility. To reach needed resolution, numerous traces are averaged, histogram is a fast way to check how long the signal stay outside a thin window.

4-Automatic Sequencing

At this point, the Test Tool is already a fine tool for lab usage but needs people to launch measurements. Hopefully, EMA is a sw manager enabling automatic sequencing in a very convenient way for users. User has just to place within a same directory path any procedure file he would want to execute in a sequence. The directory path may be freely chosen, it may contains subdirectory to group elementary tests. As user can place elementary procedures files wherever the os let him do, one can built automated sequence as needed.

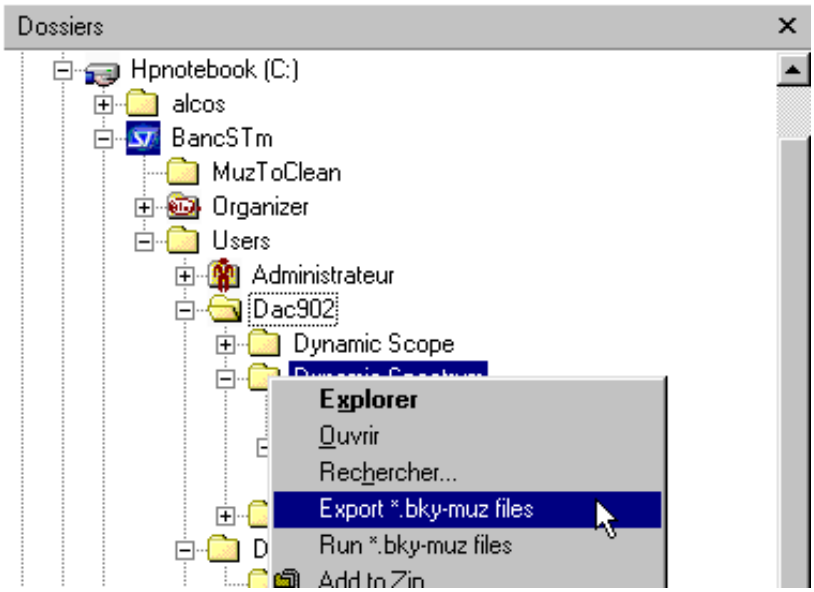


Launching an automatic sequence may be done from MS/Explorer itself, once the upper directory of the sequence is selected.

A text log file is available at end of sequence execution to get a summary (each individual procedure file contains results and detail related log).

5-Getting Results Reports

•Exporting Full Sub-Tree Results



Same functionality as for automatic execution may also be used to select a full directory to export (contextual menu "Export *.bky-muz files").

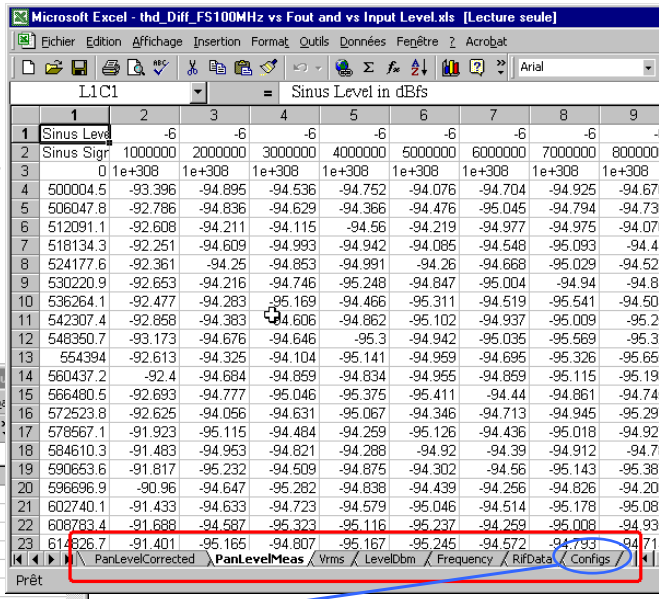
It enables the automatic generation of MS/Excel related files.

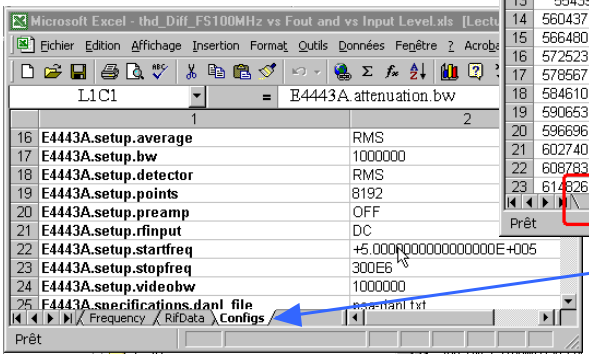
NB : Individual export of one file is available as well from contextual menu, or even from opened file.

Exported files get same name as original one, but the extension will be changed from ".bky-muz" to ".xls".

•Saving Full Traceability along the whole process

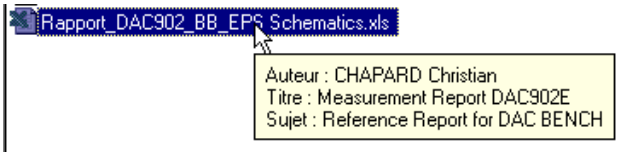
Exported files does contains results, that's the main concern of the process. But to be really usable, results aren't enough! One must be able to know how measurements were done to get these results. To be efficient, and also to enable full traceability, complementary information are coming along with results using different sheets of the same workfile.
Complementary information are direct measurements values, intermediate computed results if any, and always all the individual parameters values for each instrument used.



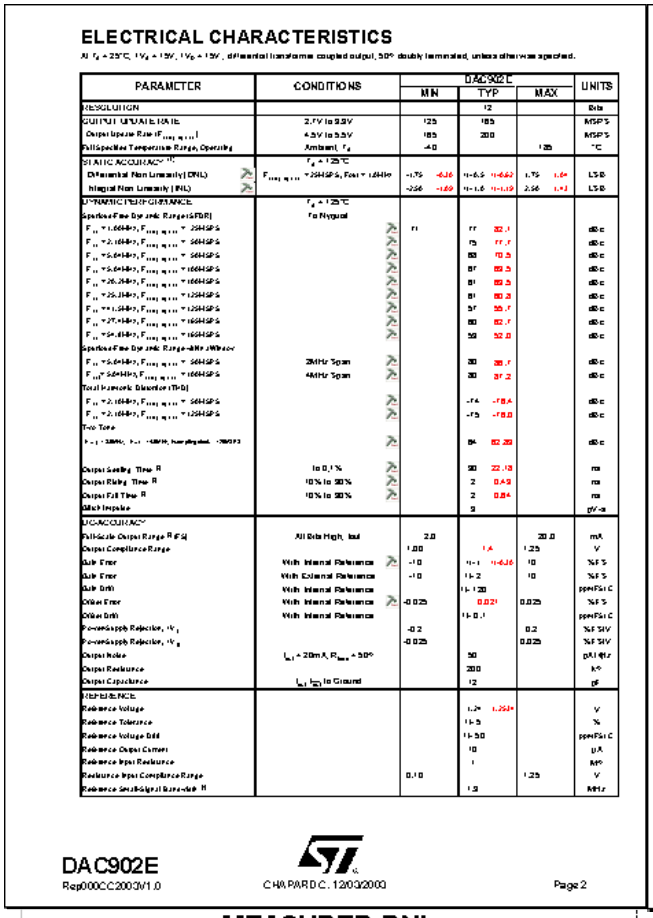


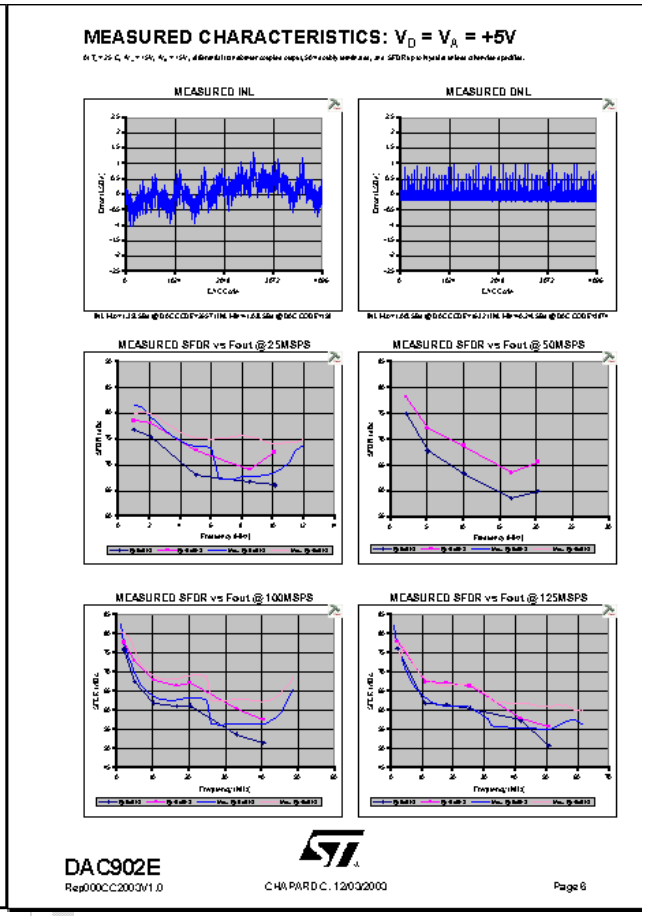
•Using Standard Spread Sheet Tool Facilities

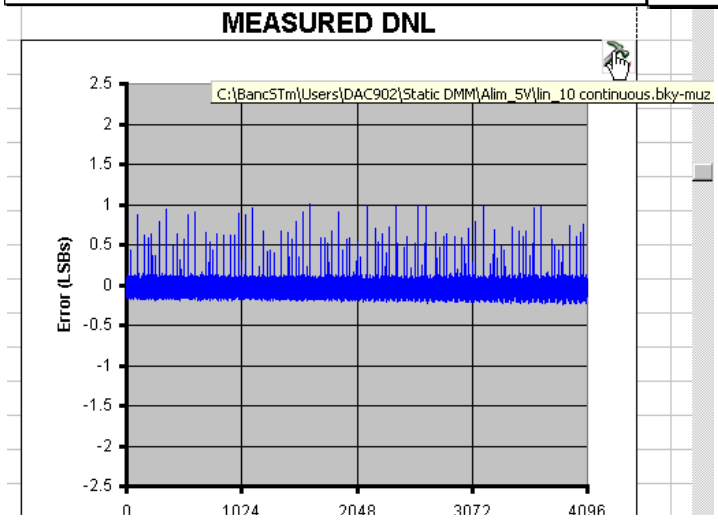
If user builds his own MS/Excel file, linked to exported result files (file names are predictable, localization may be relative), a complete results automated reporting will be done (ie : Rapport_DAC902_BB_EPS Schematics.xls).



Using such link between a unique report workfile and all the individual measurement procedures enables to obtain valuable presentation, with full traceability for each result (here are two pages extracted from preview) :





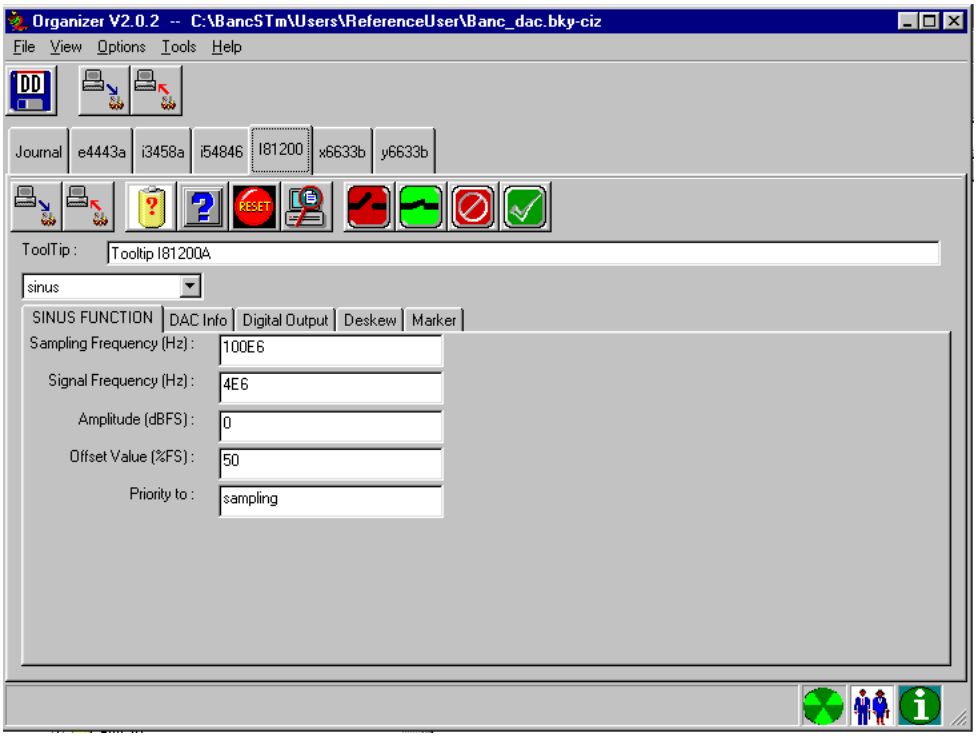


Even, using Hyperlink facilities of MS/Excel, user is able to launch measurement procedure related to select results he is studding.

At this level, a mouse click shows impact on result reports from modifying any measurement condition, or using another DUT.

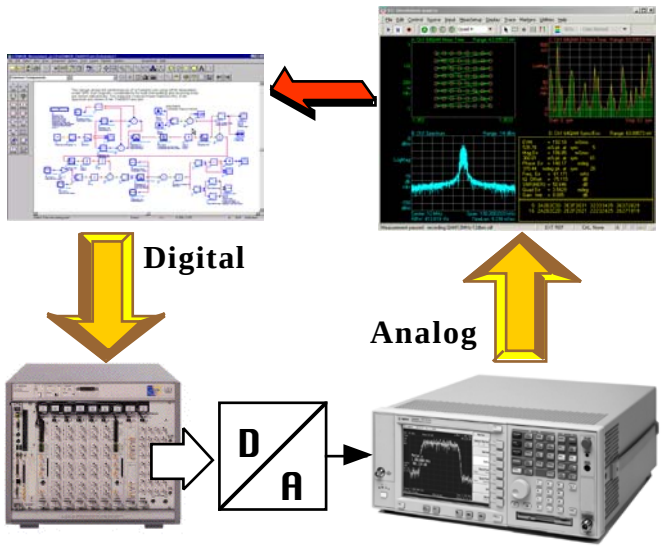
With such facilities, the global MS/Excel report isn't only a results presentation document, but at the same time the unique entry point for any new measurement on same product to test.

6-Some other DAC test tool capability



By itself, EMA sw enables user to interact with bench equipments.
Any user may use special file type able to deal with a group of instrument device.

Using any instrument front panel, user can adjust required configuration and the UpLoad it to the "Instrument File Group". This can be done for any instrument from the group, and symmetric DownLoad function is also available.
As for measurement procedures, instrument file group may be freely named and stored anywhere (upon os security policy).



Advanced Design with ADS

For instance, the VXI 81200 Digital Generator is able to deliver different signal type (signal type is the waveform name at digital DAC under test output). There is a special "custom" signal available, that means the user can build himself the digital suite to input to the DAC.
This "custom" signal may also be coming from ADS, and for instance it would be interesting to get some real world digital modulation. In such a case, full instrument bench configuration may be saved (including any digital modulation 'custom' signal as QAM64, ...).

Using VSA 89600 sw suite, PSA from the standard system may be used to demodulate "real-world" modulation sent to DAC under test with 81200 VXI Digital Generator. The demodulated signal may then be re-used inside ADS as "real-world" DAC output in simulation purpose.

Standard ADS enable connected simulation link for some equipment like ESG generator or PSA analyzer. The Advanced Test Tool for DAC using EMA sw enables usage of Agilent 81200 digital pattern generator with ADS.

7-Additional Information

•How does EMA works

User interface drives Python[1] modules. User interface is one from :

-standard MS/Win tool customized for needs (ie : MS/Explorer with special contextual menu)

-any executable able to resolve specific needs (ie : instrument panel interface, results data, ...)

Python modules are in charge of mass storage and related tasks, it deals through TCP/IP link with specialized Test & Measurement application.

The T&M application itself is built as a core, dynamically loading needed parts specialized for each device or measurement procedure. T&M modules are the only specific parts form the whole software architecture. In the "Advanced Test Tool for DAC" case, T&M modules consist of :

-One "driver" for each instrumentation device (ie : 81200, 6633B, 3458A, 54846A, E4443A)

-One "measurement procedure" for each elementary automated measurement (ie : LIN, TIMING, THDPAN)

The customisation needed to replace one instrument device by an other one (ie : want to use sampling frequency as high as 2.67 Gb/s) is to check actual 81200 driver ability to use new Generator Modules (E4861A rather than E4832A) and Front End (E4862A rather than E4838A), and then upgrade it if needed.

Using EMA manager, other Test Tool may be build using actual Test Tool equipment and adding needed devices to achieve new measurement (ie : Analog to Digital Converter Test Tool will need analog generator and digital analyzer).

It means the system is able to scale your performance needs as well as the different DUT type you have to verify. All that in adding only new specific hw and related sw, without change on existing.

•About s/w Tools Used by EMA

EMA concept was designed to be used for years, with different measurement systems, one of the first rules was to choose as standard and independent from os as possible tools. On another hand, today most used operating system is MS/Windows.

Furthermore, obviously the measurement sw part and the management and user interface sw part are different in many way. A good idea is to use dedicated tool to each one, but to get some strong and widely used standard to communicate.

- •Management sw (also called Organizer) uses Python[1] language, this GNU is available for most of current operating system, including MS/Windows and Linux.
- •T&M sw (also called BkTM) uses HTBasic[2] language, through SICL interface library this tool is able to use GPIB or LAN link to deal with instruments. The RMB core is available for MS/Windows and Linux (as well as latest HP-UX 11i).
- •The communication layer between the two sw parts uses TCP/IP, enabling to run on the same machine or through LAN

Python[1] to find more about Python : www.python.org
HTBasic[2] to find more about HTBasic : www.htbasic.com

•Agilent Equipment

-Digital Pattern Generator
VXI 81200 System with :
E4805A Central Clock Module (1kHz to 670 MHz, 1Hz resolution)
E4832A Generator Module (2 Mbit/channel)
E4838A Front End (670 MHz, differential, 3.5 Vpp)

-Power Supply
6633B 100W high performance with output current measurement capability in the microampere range

-DMM
3458A 8.5 to 4.5 digit resolution, up to 100,000 readings/sec, 8ppm/year voltage reference stability

-Oscilloscope
54846A 4 channels, 2.25 GHz bandwidth, 8 GSa/s sample rate, 64K memory depth

-Spectrum Analyzer
E4443A 3 Hz to 6.7 Ghz Frequency Range, 1 Hz to 8 MHz Resolution Bandwidth, 0 to 70 dB Attenuation in 2 dB steps

-Interface & sw Library
82350B PCI/GPIB interface
E58410A LAN/GPIB gateway
E2094L SICL for Windows sw

Thanks to :
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