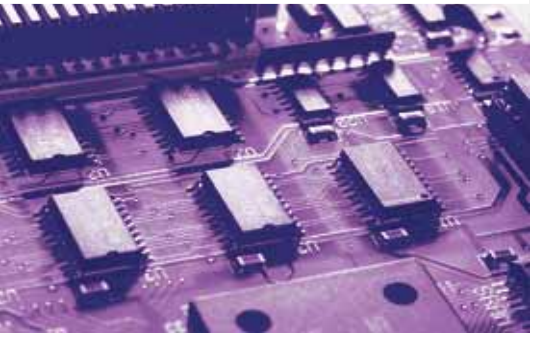
Lightning Tests



EMC - PARTNER

Avionics Test System

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Brief Overview of Phenomena

Studies by the Federal Aviation Administration (FAA) reveal that the average civil aircraft is struck by lightning every 1000 flight hours. It is therefore imperative that all aircraft should be tested to withstand the effects of lightning.

Lightning events differ mainly in current amplitude, in the transferred charge and in the impulse shape of the lightning current. Two lightning events need to be simulated:

- the direct strike (current and voltage) and
- the induced currents and voltages within an aircraft resulting from a direct strike.

Induced lightning current, voltage waveforms and impulse generator impedance values required to create these waveforms have been measured on avionic systems within aircraft subjected to direct strike events.

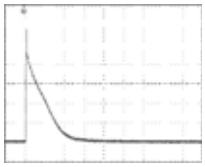
Test standards including MIL-464 and DO-160 specify both direct and induced strike pulse sequences and levels. RTCA/DO-160 section 22 mandates that three sequences of pulses shall be used for induced lightning testing of avionics:

- single stroke (SS),
- multiple stroke (MS) and
- multiple burst (MB).

SS events are used for damage assessment on avionics subsystems and equipment. MS and MB events are applied to determine the electromagnetic compatibility of system, subsystems, and equipment. Multiple stroke and multiple burst events were specified for the first time in Revision 3 of DO-160 D; although they have been anticipated for a number of years and even recommended by the FAA Advisory Circular AC 20-136 and manufacturer specific testing protocols.

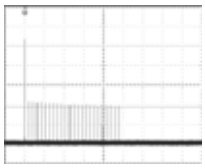
In addition to the lightning induced transients, lower level transients caused by switching and other platform related phenomena are also a disturbance source within the avionic system. These phenomena are described in DO160 section 17, 19 and 25. For section 25 test equipment see our brochure “ESD Testers”.

EMC PARTNER aircraft generators can replicate the following phenomena:

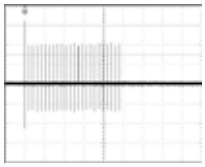


- **Single Stroke**
  Single stroke events are used for damage assessment on avionic sub-systems and equipment. They can be divided into PIN injection and Cable bundle tests.

  PIN transients are applied directly to the system interface circuits and are used to assess the dielectric withstand voltage or damage tolerance of the interface components. Cable bundle tests are performed using an injection probe to couple transients. Tests are performed on fully configured functioning equipment to determine equipment survivability.

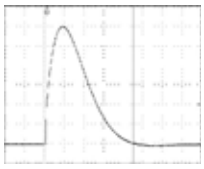


- **Multiple Stroke**
  Typical lightning events include several high current strokes following the first return stroke. These occur at intervals of several milliseconds as different pockets in the cloud feed their charge into the lightning channel. Another source is the swept channel process. If a fast moving aircraft experiences a direct strike, the points of arc attachment are likely to be swept backward along the aircraft since the lightning channel tends to remain stationary relative to the surrounding air.



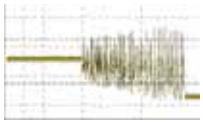
- **Multiple Burst**
  These pulses may result from lightning leader progression or branching. The pulses appear to be most intense at the time of initial leader attachment to the aircraft. Transient responses arising from the magnetic field of the external environment (component H) of the multiple burst waveform set will also occur in the induced multiple burst sequence. The predominant waveform responses are the damped sinusoidal waveform 3 in a frequency range between 1 to 10 MHz.

- **Voltage Spike**
  Voltage spikes can appear on the AC or DC power supply interfaces due to platform power supply switching transients. These are transmitted by interconnecting cables and appear at an equipment interface on the power supply pins. Disturbances on AC power lines could be synchronised to particular phase angles of the 400Hz supply.

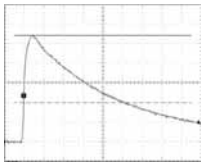


- **Induced Signal Susceptibility**
  These transients result from inductive switching and similar events within the installation, that are transmitted through interconnecting cables to an equipment interface.

  Such transients are mostly derived from the on-board power equipment and relate to the power supply frequencies and harmonics.



- **Electrostatic Discharge**
  The low relative humidity and temperature in an aircraft together with extensive use of synthetic materials for floor and seat covering and plastic structures all contribute to the likelyhood of persons becoming electrostatically charged. Personnel can become charged to several tens of kilovolts. During normal operation or servicing, discharges from personnel could result in damage to electronic equipment.



Applicable Standards

Radio Technical Commission for Aeronautics (RTCA)

DO-160 : Environmental Conditions and Test Procedure for Airborne Equipment.

- Section 17: Voltage Spike.
- Section 19: Induced Signal Susceptibility.
- Section 22: Lightning Induced Transient Susceptibility.
- Section 25: Electrostatic Discharge (ESD).

European Organisation for Civil Aviation Equipment (EUROCAE)

EUROCAE / ED-84 (1997): Aircraft Lightning Environment and related Test Waveforms. Report of EUROCAE WG-31 and SAE Committee AE4L.

US Department of Transportation, Federal Aviation Authority (FAA)

Advisory Circular 20-136 (1990): Protection of Aircraft Electrical/Electronic Systems against the indirect effects of lightning.

International Standards Organisation (ISO)

ISO 7137 (2001): Aircraft - Environmental conditions and test procedures for airborne equipment.

Test System Overview

Test System Features

- Full level 5 capability for all waveforms
- Clean reproducible waveforms
- Modular construction allows for future expansion
- Simple operation
- Parameter change during operation (+/-)
- Internal program memory
- Electronic polarity change
- Compact designs
- Fulfills ALL transient requirements
- Remote control and software upgrade through standard interface
- Full range of accessories
- 2 year warranty

User Benefits

The technical excellence and many unique features of EMC PARTNER avionics generators translate directly into benefits for the user:

- Cost effective solutions to meet many test requirements
- Simple extension to meet higher test levels or new requirements
- Increase quality of test object
- Real time parameter change, ideal development tool
- Save operator time with the automated test routines and test report facility
- Unparalleled reliability and system up-time

MIG0600SS

MIG0600MS

Generators

The EMC PARTNER family of avionics test generators simulate EMC events that have been observed in aircraft systems and cabling. These events are due to external lightning events and internal platform generated transients. EMC PARTNER avionics generators are available in a number of versions which can be upgraded to give enhanced test capability at a later date.

A wide range of accessories are available to facilitate testing. Coupling transformers for cable diameters up to 7.5cm and Line Impedance Stabilisation Networks (LISNs) complete the system.

- **MIG0600SS and MIG0600MS**
  Waveforms WF1, WF4, WF5A & WF5B. Used for PIN injection and single stroke cable bundle testing up to level 4. The MIG0600MS is an extension to the MIG0600SS which adds multiple stroke capability.

  MIG0600SS & MS generators share the same basic construction so, while they are not completey modular, the single stroke can be easily upgraded to multiple stroke. Multiple stroke patterns are pre-programmed that cover all current requirements. Additionally, user defined patterns can be assembled on a PC using the EMC PARTNER FW-Load software and uploaded into the MIG0600MS. A maximum of 24 pulses can be programmed in each stroke with the amplitude of the subsequent strokes variable under user control.

- **MIG0618SS**
  Waveforms WF1, WF4 & WF5A. This is a stand-alone generator that delivers single stroke waveforms in excess of the level 5 cable bundle requirement.

  Extending the single stroke system to achieve test levels of 5 and above, is possible using the MIG0618SS. This stand alone unit generates WF1, WF4 and WF5A as a compliment to the MIG0600SS.

- **MIG-OS-MB**
  Waveforms WF2 & WF3 (1MHz & 10MHz). Used for WF2 multiple stroke and WF3 multiple burst tests on cable bundles.

  Unique in it's class, MIG-OS-MB is factory programmed to perform all current multiple stroke and multiple burst patterns. Additionally, users can define and upload any new pattern, making MIG-OS-MB the most flexible system available.

- **MIG-OS-MB-EXT**
  Waveforms WF2, WF3 (1MHz & 10MHz) & WF6H. Used for WF2 multiple stroke and WF3 and WF6H multiple burst tests on cable bundles.

  The MIG-OS-MB generator can be further enhanced by addition of the MIG-OS-MB-EXT which increases the test level of impulses including waveform 2 (WF2) single and multiple strokes, waveform 3 (WF3) single and multiple strokes and adds the EUROCAE waveform 6H multiple burst.

- **MIG2000-6**
  Special modules are available for section 17 (voltage spike) and section 19 (induced signal susceptibility).

  The system is completed with couplers and spike synchronisation on the power supply frequency up to 400Hz.

  Please refer to the Military Test System brochure for further information.

- **ESD3000**
  Special modules are available for section 25 (Electrostatic Discharge).

  ESD3000 is a light weight, hand-held battery operated tester. A range of changeable Discharge Modules (DMs) and Discharge Networks (DNs) are available. ESD3000 architecture allows customer specific requirements to be simply and quickly realised.

Remote control of EMC PARTNER avionics test systems is possible using the EMC PARTNER TEMA software package. This is greatly enhanced by the free to download DATABASE software which provides additional hints and contains predefined generator setup files.

EMC PARTNER has test equipment to simulate four component tests on complete aircraft. For further information please contact EMC PARTNER directly.

System Flowcharts for WF1, WF4, WF5A and WF5B

The following flowcharts illustrate EMC PARTNER equipment configurations necessary to perform single stroke, multiple stroke and PIN injection tests in accordance with DO160 section 22.

- **Cable Induction**
  The CN-GI-CI coupler is used to inject waveform 1, 5A and 5B into EUT cabling.

  Waveforms are induced into interconnecting cables and power leads.

- **Ground Injection**
  The CN-GI-CI coupler is used to inject waveforms 4 and 5 into cable grounds.

  The injected waveforms are applied between cable shields and any return path to the local ground plane.

- **PIN Injection**
  Waveforms 3, 4 and 5A are applied directly from the generator output to designated pins on an EUT connector, usually between each pin and case ground.

MIG0618SS

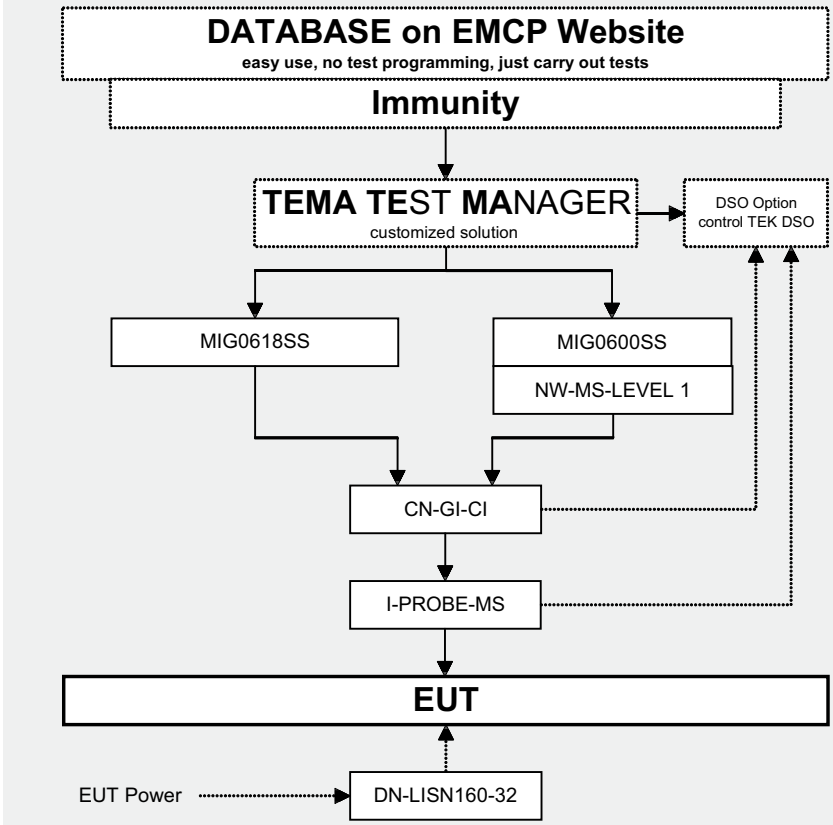
MIG-OS-MB

MIG-OS-MB-EXT

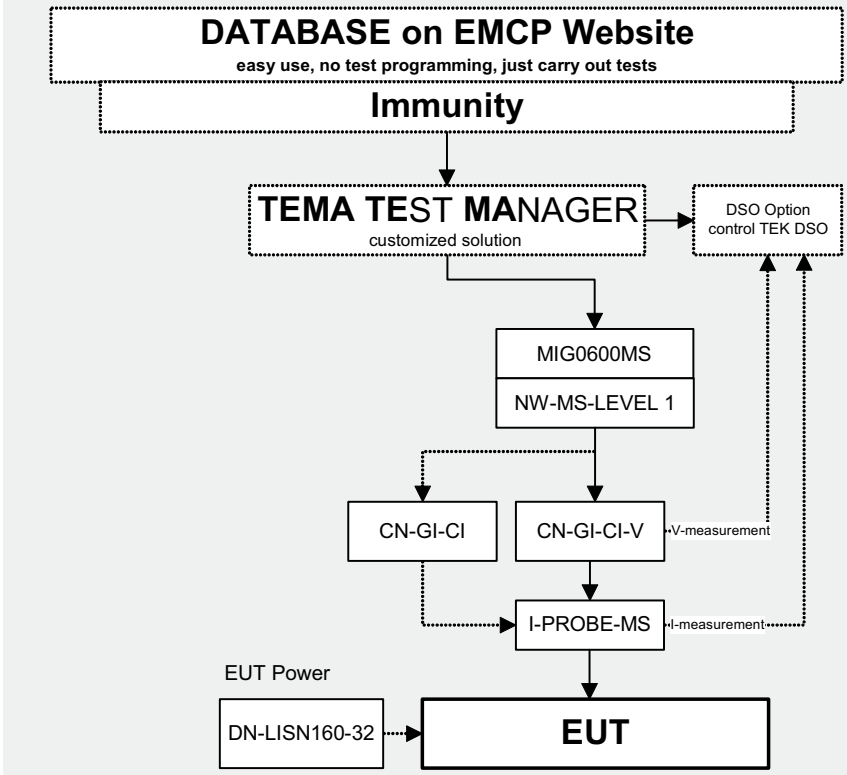
MIG2000-6

ESD3000

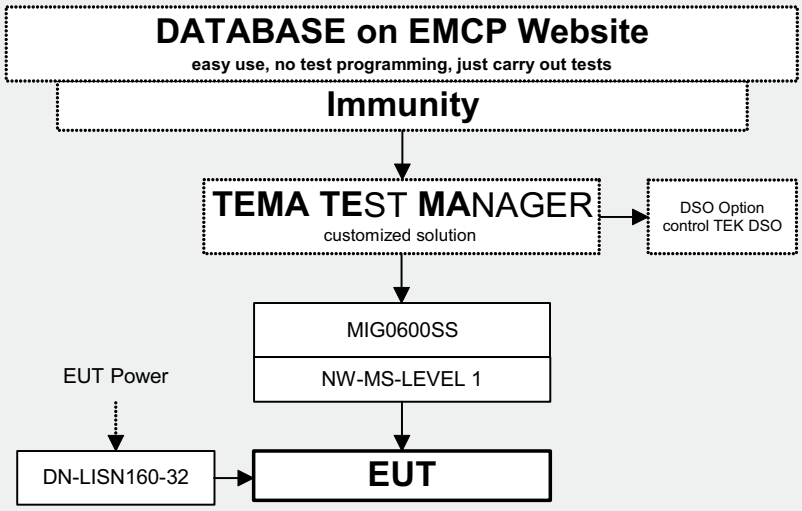
Single Stroke



Multiple Stroke



PIN Injection



System Flowcharts for WF2 and WF3

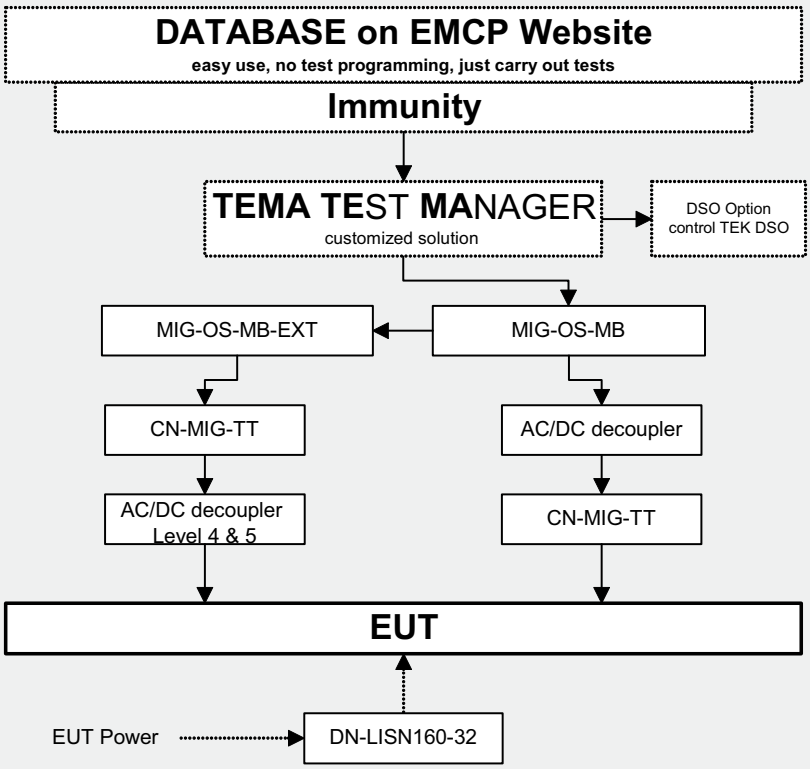
The following flowcharts illustrate EMC PARTNER equipment configurations necessary to perform multiple burst, multiple stroke and PIN injection tests in accordance with DO160 section 22.

- **PIN Injection**
  Waveform 3 is applied directly from the generator output using the CN-MIG-TT to designated pins on an EUT connector, usually between each pin and case ground. For powered PIN testing the CDN-BDBC should be used.

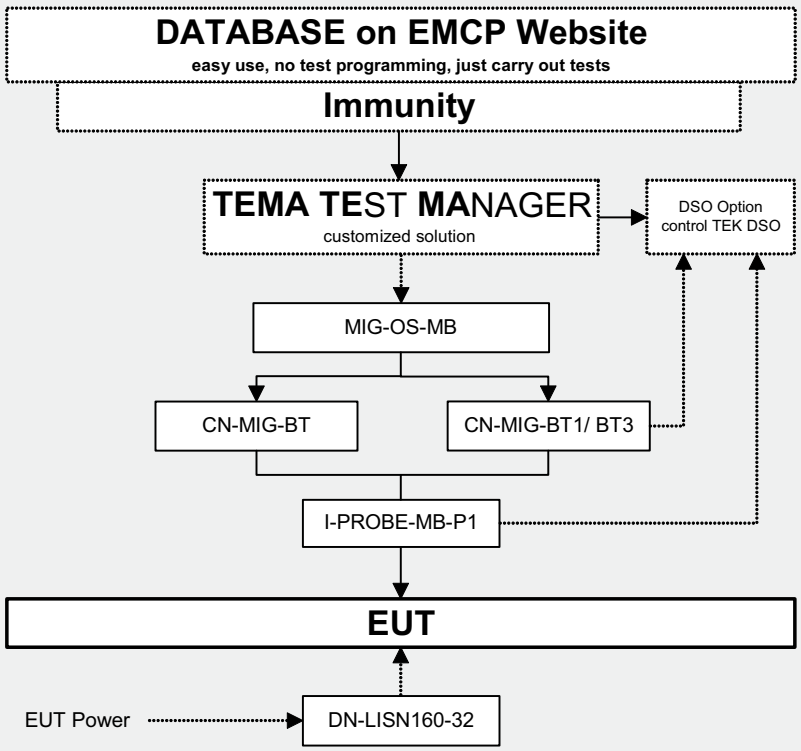
- **Cable Induction**
  The CN-MIG-BT, -BT1 or -BT3 A are used to inject waveforms 2 and 3 into interconnecting cables and power leads.

PIN Injection

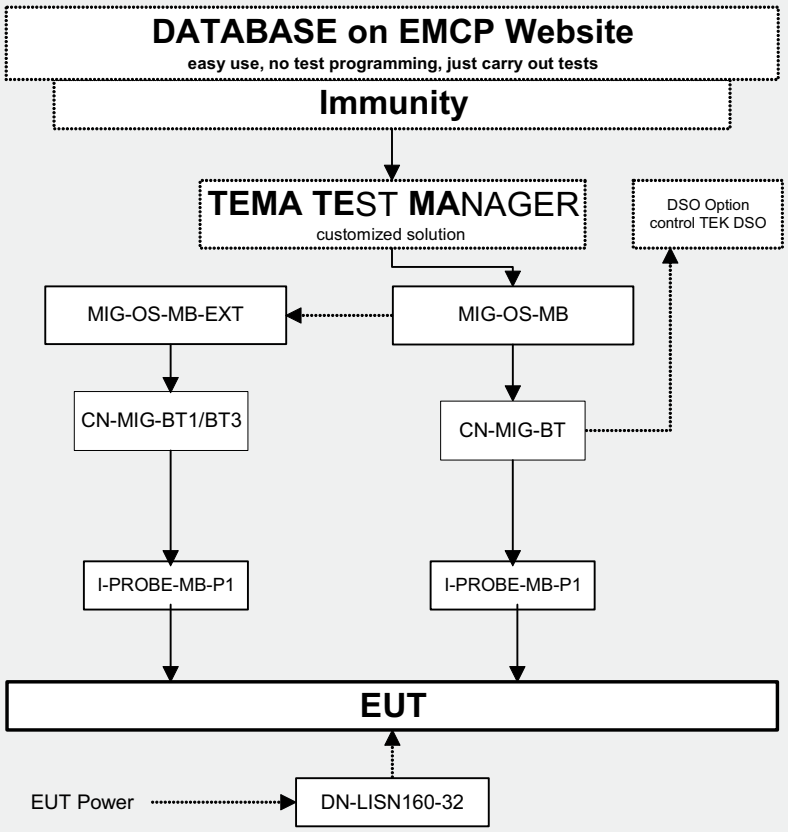
For testing up to level 3, the CN-MIG-TT with AC/DC decoupler is provided. Level 4 and 5 require the MIG-OS-MB-EXT with special AC/DC decoupler.



Multiple Burst

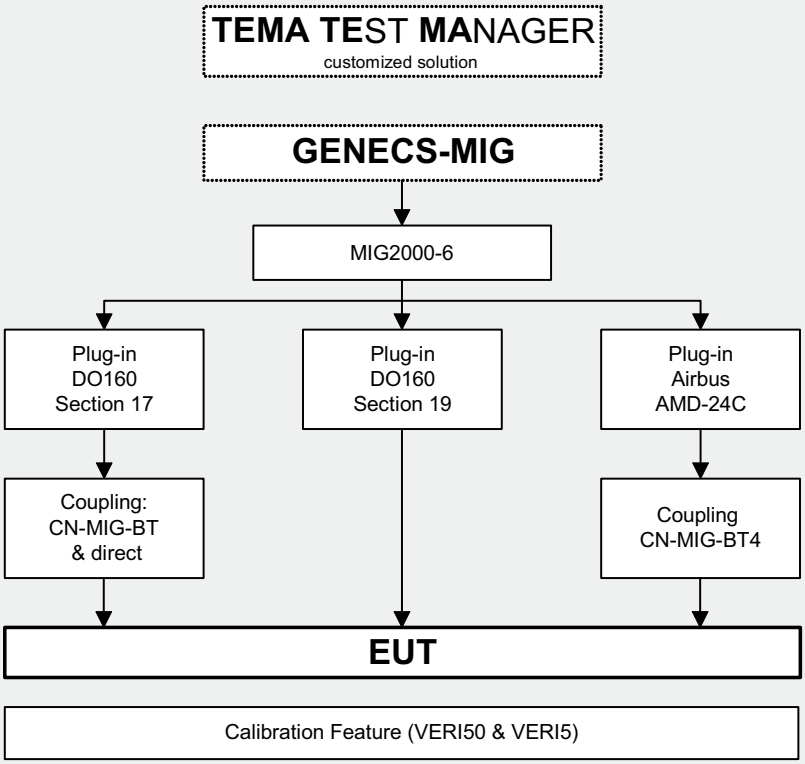


Single Stroke and Multiple Stroke

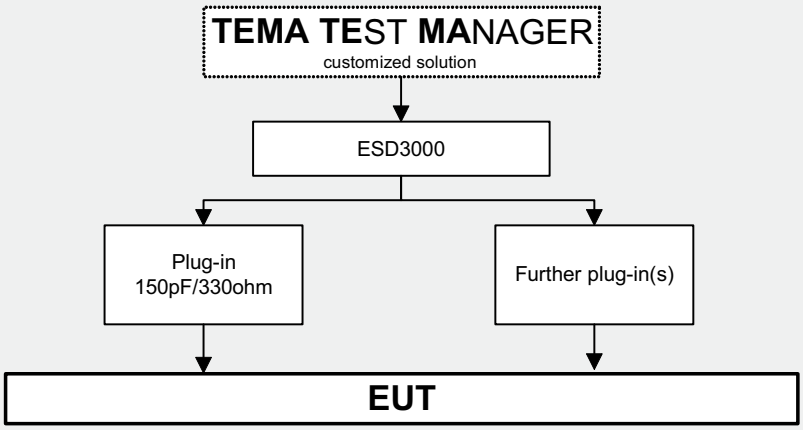


Flowchart for Voltage Spike and Induced Susceptibility Tests

The following EMC PARTNER equipment is used to perform tests in accordance with DO160 section 17 and 19.



ESD Test Equipment for DO160 section 25



Generator Specifications

MIG0600SS and MIG0600MS

DO160 Waveforms	W1, W4, W5A & W5B
W1 - 6.4/70µs	15A up to 1600A (3200A) [1]
W4 - 6.4/70µs	75V up to 1600V
W5A - 40/120µs	75A up to 2000A (10000A) [1]
W5B - 50/500µs	75A up to 2000A (5000A) [1]

MIG0600MS only

Multiple Stroke pulse spacing	10ms up to 500ms
Stroke duration	0.01 up to 50s
Repetition	60 up to 999s
Maximum pulses	25 every 10 s
First peak A1	160V up to 3200V
Subsequent peaks A2	50V up to 400V
Multiple stroke pattern	user programmable

MIG0618SS (Level 4 and 5 Extension)

DO160 Waveforms	W1, W4 & W5A
W1 - 6.4/70µs	250A up to 4000A
W4 - 6.4/70µs PIN injection	125 up to 3200V
W4 - 6.4/70µs Ground injection	125 up to 3200V (6400A at 3200V) [1]
W5A - 40/120µs PIN injection	125 up to 3200V (3200A at 3200V) [1]
W5A - 40/120µs Ground injection	400A up to 6000A (10000A) [1]

MIG-OS-MB

DO160 Waveforms	W2 & W3
W2 - 0.1/6.4us	40 up to 1600V
W3 - 1MHz	80 up to 3200V
W3 - 10MHz	80 up to 3200V

MIG-OS-MB-EXT (Level 4 and 5 Extension)

W2 - 0.1/6.4us	750 up to 5000V
W3 - 1MHz	1000 up to 5700V
W3 - 10MHz	1000 up to 4500V

Multiple Stroke

Pulse spacing	10ms up to 500ms
Duration	0.01 up to 2s
Repetition	2 up to 999s
Maximum pulses	30 every 2s
Multiple stroke pattern	user programmable

Multiple Burst

WF3 - 1MHz	50 up to 3200V
WF3 - 10MHz	50 up to 3200V
Pulse spacing	10µs up to 10ms
Burst duration	0.001 up to 2s
Burst pattern	user programmable

1) Figures in brackets indicate system level with coupler.

MIG2000-6

Fx-DO160-S17

DO160 Section 17 waveform	Voltage Spikes
Amplitude range	100 to 1100V
Source Impedance	50ohm
Risetime	1 to 2µs
Duration	10µs ± 20%
Repetition	up to 2Hz
Synchronisation	50/60/400Hz
Coupling	Serial injection using CN-MIG-BT

Fx-DO160-S19

DO160 Section 19 waveform	Induced Signal Susceptibility
Amplitude range	100 to 1000V
Spike duration	4µs
Burst duration	250µs
Coupling	Serial using wire coil

Fx-AMD24C

ABD0100.1.8 waveform	Voltage Spikes
Test Supply Voltage	115V
Risetime	< 2µs
Source Impedance	50ohm
Spike Duration	10µs
Amplitude Range	200 to 1200V
Source Impedance	5ohm
Spike Duration	50µs
Amplitude Range	100 to 650V
Spike Duration	100µs
Amplitude Range	100 to 500V
Spike Duration	200µs
Amplitude Range	50 to 150V
Spike Duration	400µs
Amplitude Range	50 to 200V
Coupling	Serial injection using CN-MIG-BT4

ESD3000

Please refer to ESD Test System brochure for further information.

Accessories and Options

DN-LISN160-32

Decoupling network for cable bundle and ground injection tests.

Application: To provide a defined system impedance for impulse tests according to DO160 section 22.

DN-LISN160-32

CDN-BDBC

Blocking device (BD) and bypass circuitry (BC).

Application: For power pin testing in accordance with DO160 section 22.

CDN-BDBC

MIG0600SS, -MS and MIG0618SS only

CN-GI-CI

Current coupling transformer used with WF1, WF5A and WF5B.

Application: For cable bundle and ground injection in accordance with DO160 section 22.

CN-GI-CI

NW-MS-LEVEL1

External attenuation box to reach level 1 voltages and currents.

Application: For all single or multiple stroke waveforms in accordance with DO160 section 22.

NW-MS-LEVEL1

I-PROBE-MS

High bandwidth current transducer. Clamp-on type with large opening.

Application: Measurement of current amplitudes for WF1, WF5A and WF5B in the EUT cables in accordance with the DO160 section 22.

I-PROBE-MS

CN-GI-CI-V

Voltage coupling transformer used with WF4, WF5A and WF5B.

Application: For cable bundle and ground injection in accordance with DO160 section 22.

CN-GI-CI-V

OPTION-V to CN-GI-CI

Extends current coupling transformer CN-GI-CI for voltage testing up to level 3 used with WF4 and WF5A.

Application: For cable bundle and ground injection in accordance with DO160 section 22.

CN-GI-CI-V

CN-CI-CI

Coupling Transformer for cable induced tests, applicable for the following waveforms WF1, WF5A, WF5B up to 5000A. **EUT cable only one turn**, aperture 6 x15 cm

CN-GI-CI-V

CN-CI-VI

Voltage coupling transformer for voltage waveform WF4 and WF5A coupling for SS and for MS up to L3

EUT cable only one turn

Aperture 6 x15 cm

CN-GI-CI-V

CN-CI-VI (2x)

Voltage coupling transformer for voltage waveform WF4, WF5A and WF5B.

WF4 SS up to L5, MS up to L4

WF5A SS up to L4, MS up to L4

WF5B SS up to L2

EUT cable only one turn

Aperture 6 x15 cm

2x CN-CI-V1

CN-CI-VI (2x) + CN-CI-I1

Voltage coupling transformer for voltage waveform WF4, WF5A and WF5B.

WF4 MS up to L4

WF5A SS up to L5, MS up to L5

WF5B SS up to L3

EUT cable only one turn

Aperture 6 x15 cm

2x CN-CI-V1 + CN-CI-I1

MIG-OS-MB

MIG-OS-MB-EXT

This extension enhances MIG-OS-MB's capability by increasing test levels and including additional waveforms. The extension is automatically recognised and controlled by the MIG-OS-MB firmware. The following plug-ins are available for the extension:

NW-WF2-FS

Waveform WF2: 0.1/6.4µs extends the MIG-OS-MB to level 5 for single stroke or first stroke testing.

NW-WF2-SS

Waveform WF2: 0.1/6.4µs extends the MIG-OS-MB to level 5 for subsequent stroke testing.

MS definition: 1A 100%, 23D/2 50% within 2 seconds randomly distributed from 50ms up to 110ms. Requires NW-WF2-FS.

NW-WF3-1M-FS

Waveform WF3: 1MHz extends the MIG-OS-MB to level 5 for single stroke and first stroke testing. No burst possible.

NW-WF3-1M-SS

Waveform WF3: 1MHz extends the MIG-OS-MB to level 5 subsequent stroke testing. No burst possible.

MS definition: 1A 100%, 13D/2 50% within 1.5 seconds randomly distributed from 50ms up to 110ms. Requires NW-WF3-1M-FS.

NW-WF3-10M-FS

Waveform WF3: 10MHz extends the MIG-OS-MB for single stroke and first stroke testing. No burst possible.

NW-WF3-10M-SS

Waveform WF3: 10MHz extends the MIG-OS-MB for subsequent stroke tesing. No burst possible.

MS definition: 1A 100%, 13D/2 50% within 1.5 seconds randomly distributed from 50ms up to 110ms. Requires NW-WF3-10M-FS.

NW-WF6H-MB

Waveform 6H: 0.224/4µs impulse.14 pulses multiple burst only.

MIG-OS-MB-EXT

Example of a plug-in

CN-MIG-BT

Coupling transformer for cable bundles up to 3.5 x 6cm.

Application: For WF2 and WF3 up to level 3 in accordance with DO160 section 22.

CN-MIG-BT

CN-MIG-BT1

CN-MIG-BT1

Coupling transformer for cable bundles up to 3.5 x 6cm. Includes 0.1ohm calibration shunt.

Application: For all multiple stroke and multiple burst waveforms in accordance with DO160 section 22.

CN-MIG-BT3

CN-MIG-BT3

Coupling transformer for cable bundles up to 8cm diameter. Includes 0.1ohm calibration shunt.

Application: For all multiple stroke and multiple burst waveforms in accordance with DO160 section 22.

CN-MIG-TT

CN-MIG-TT

Coaxial test tip for PIN injection. Provides AC/DC decoupling. Set includes verification equipment and measurement adapter.

Application: For use with MIG-OS-MB (WF2 & WF3) in accordance with DO160 section 22.

I-PROBE-MB-P1

I-PROBE-MB-P1

High bandwidth current waveform transducer. Opens to cause minimum disruption to the circuit under test.

Application: To measure the current waveform and amplitude for WF2 and WF3 in the EUT cable in accordance with DO160 section 22.

AC-DC Decoupler Level 4 & 5

AC-DC Decoupler Level 4 & 5

Decoupler for use with MIG-OS-MB-EXT.

Application: PIN injection testing at level 4 and 5 using WF3 1MHz in accordance with DO160 section 22.

RES10-400M

10ohm resistor for lightning voltage damage tests with WF2.

Application: PIN injection testing according to M00RP0400435.

RES10-400M

RES20-400M

20ohm resistor for lightning voltage damage tests with WF2.

Application: PIN injection testing according to M00RP0400435.

RES20-400M

MIG2000-6 only

CN-MIG-BT with three turned calibration loop

Coupling transformer for cable bundles up to 3.5 x 6cm.

Application: Voltage spike tests in accordance with DO160 Section 17.

CN-MIG-BT with three turned calibration loop

For further accessories, please refer to the Military Test System brochure.

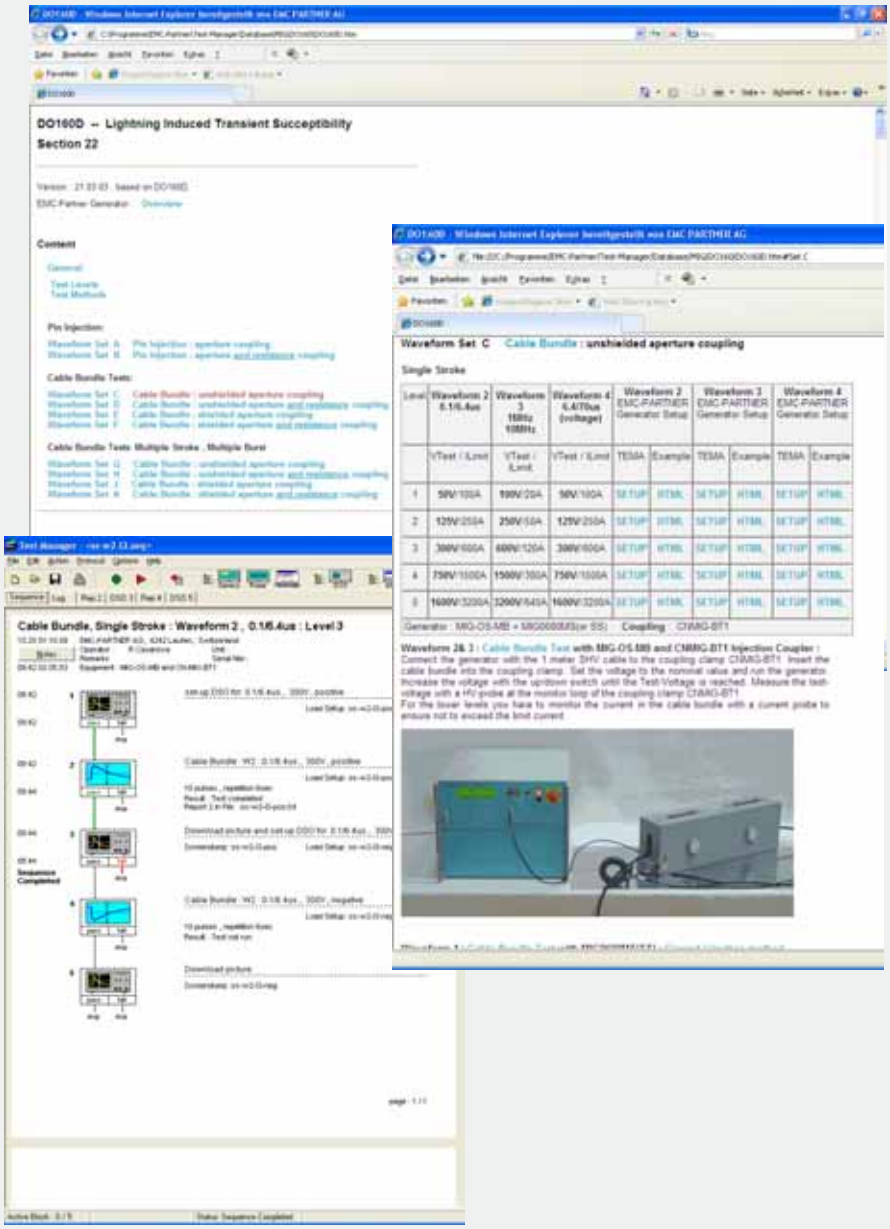
Software

For remote control of EMC PARTNER avionics generators, one of the following software packages is needed:

- GENECS-MIG: This is a relatively simple program that reproduces generator front panel functions on a PC. In addition to remote programming and control of the generators, test report information is available to word processing or other evaluation programs such as EXCEL.
- TEMA Software: Comfortable control of EMC PARTNER generators from a PC. Enables several generator types to be included in the same test sequence. Generates an enhanced level of test report.

EMC PARTNER provide a FREE downloadable software which adds another dimension to testing. The DATABASE software is a high level program that provides hints and tips for users unfamiliar with avionics testing or the EMC PARTNER generators. Generator parameters are automatically downloaded into the corresponding instrument simply be selecting the test you wish to perfom.

Predefined test routines for DO160



EEMC PARTNER's Product Range

Hid **The Largest Range of Impulse Test Equipment up to 100kA and 100kV.**

Immunity Tests

Transient Test System can be used to performs all EMC tests on electronic equipment. ESD, EFT, surge, AC dips, AC magnetic field, surge magnetic field, common mode, damped oscillatory and DC dips tests are available as stand-alone or combined test instruments. A large range of accessories for different applications is available: three phase couplers up to 690V/100A, telecom and data line couplers, verification sets, magnetic field coils. Immunity test systems fulfills IEC and EN 61000-4-2, -4, -5, -8, -9, -11, -12, -16, -18, -29.

TRA3000 and ESD3000 ideal for CE testing
Easily extended to meet other applications

Lightning Tests

A range of test equipment and accessories for aircraft, military and telecom applications. Complete solutions including all hardware and software to meet the requirements of RTCA / EUROCAE DO160 / ED14 for indirect lighting on aircraft systems, MIL-STD-461 tests CS106, CS115, CS116, for military vehicles, ITU-T .K44 basic and enhanced tests for impulse, power contact and power induction, FCC part 68 for telecom equipment testing.

MIG2000-6 – a flexible solution for military and avionic applications

Component Tests

Modular impulse generators (MIG) for transient component testing on: varistors, gas discharge tubes (GDT), surge protective devices (SPD), X Y capacitors, circuit breakers, watt-hour meters, protection relays, insulation material, suppressor diodes, connectors, chokes, fuses, resistors, emc-gaskets, cables, etc. Manual or fully automated solutions are available up to 100kA (8/20us) and 144kV (1.2/50us).

MIG1212CAP – an automatic
8 bank capacitor test system

Emission Measurements

One unit performs all measurements on the power supplies of electronic equipment and products for the CE-Mark. HAR1000 uses a novel techniques to deliver clean power source for the EUT in a compact and lightweight form. The system includes all hardware and software including line impedance networks, control and evaluation software. A basic 1-phase system can be easily extended to 3-phase by adding 2 further phases . HARCS Immunity software further expands the system by addidng interharmonic tests, voltage variation and ripple on DC tests. Complies with IEC / EN 61000-3-2, -3 IEC / EN 61000-4-13, -14,

HAR1000-3P and HARCS software
a complete test system

System Automation

As addition to the basic generators, a range of accessories are available to enhance capability. Test cabinets, test pistols, adapters and software, simplify interfacing with the EUT.

PS3 programmable source is an EMC hardened supply for frequencies form 16.7Hz to 400Hz. Frequency variation tests can be made using the PS3-SOFT-EXT. Complies with IEC / EN 61000-4-28

PS3 - programmable source
ideal for EMC applications

For further information please do not hesitate to contact EMC PARTNER's representative in your region. You will find a complete list of our representatives and a lot of other useful information on our website:

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