

Test guide **MIG-OS-MB** system „ step by step test instruction“

in accordance with DO160D-CH3



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Date: 30.08.2004
Division Manager: M. Lutz
Product Manager: J.S. Ligeard
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Aircraft Electronic - TEST GUIDE
MIG-OS-MB - Multiple Burst Testers

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1 EXPLANATION OF TEST MODES

1.1 Pin Injection Tests

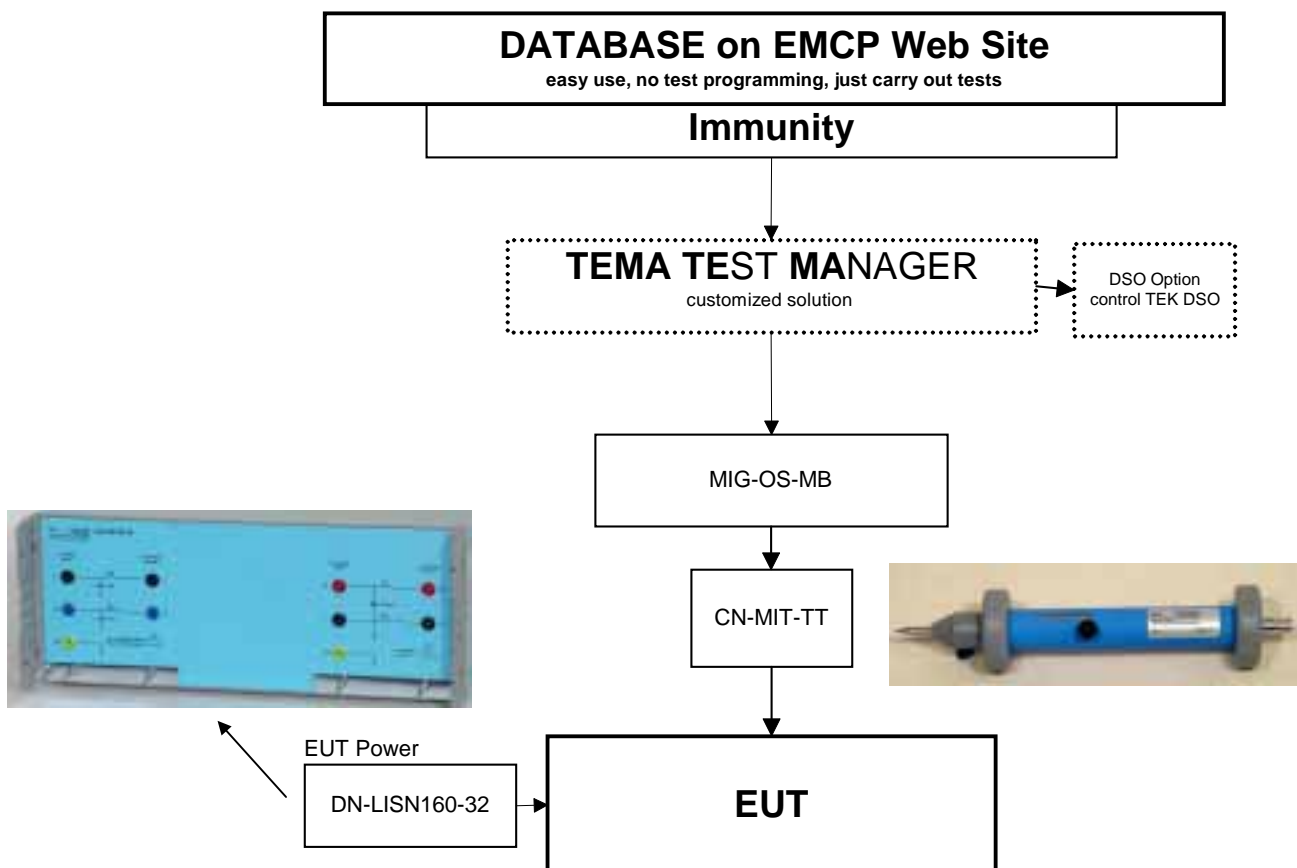
Pin injection tests are primarily for damage assessment and involve the injection of transients directly into EUT interface circuits. Levels are defined as open circuit voltage or short circuit current without any load. In the test set-up the true values of voltage or current are given by the load.

Prior to testing or at regular intervals (2 years) the waveshapes have to be verified (calibrated) as defined in the EMC-PARTNER verification report. **During the test process no waveform measurements have to be performed.**

Test-Procedure for Pin Injection :

The waveform is applied directly to the designated pins of the EUT connector, usually between each pin and case ground. The EUT is normally unpowered. Set the generator to the voltage or current according to the test level. Monitor the voltage waveform at the U-CRO output of the generator for signs of unexpected changes. When the EUT pins are powered the CN-MIG-TT must be extended with a power supply de-coupler.

Pin Injection (PIN)



1.2 Cable Bundle Tests

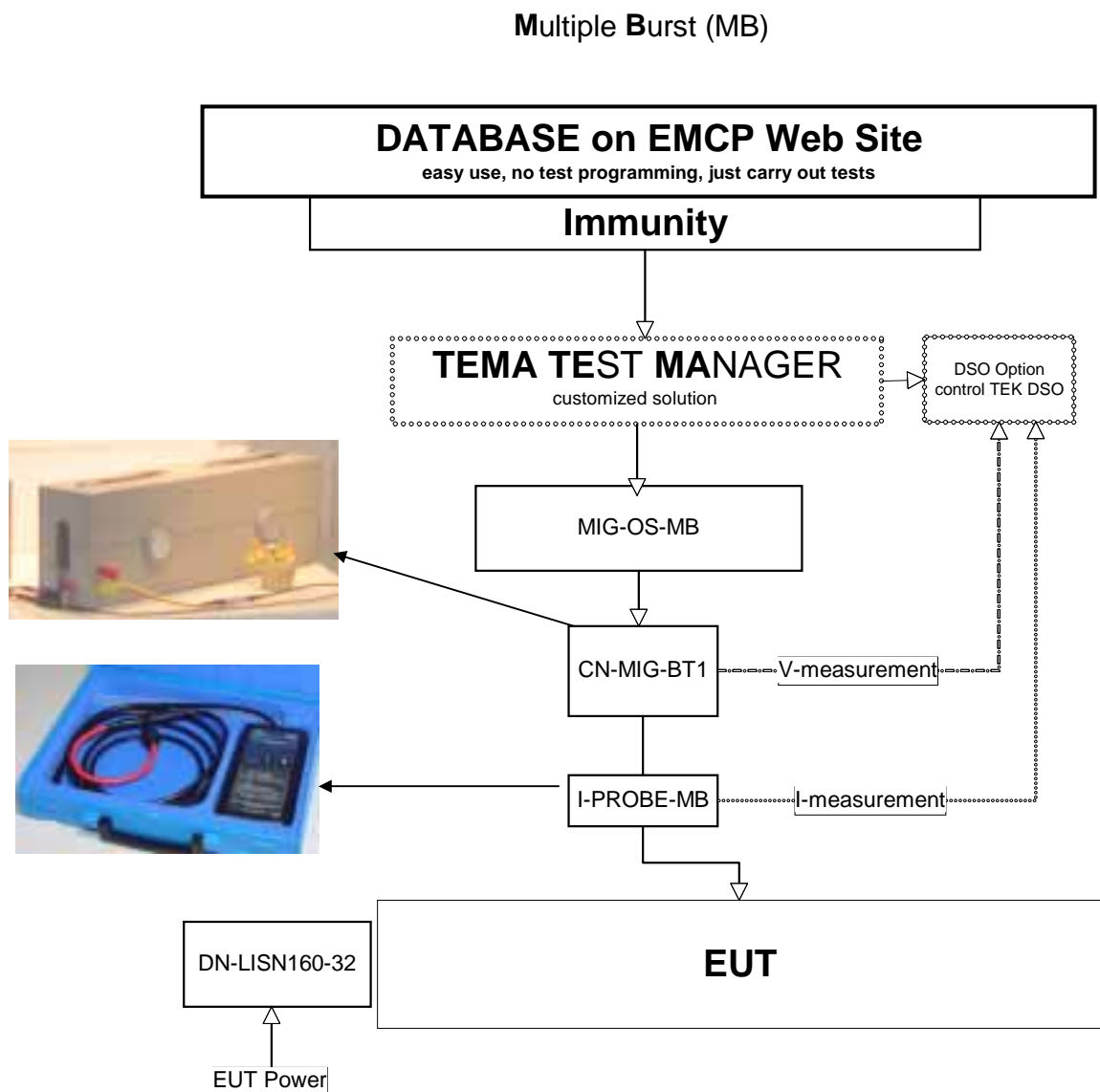
Cable bundle testing is a technique where transients are applied by **cable induction or ground injection**.

The test must be performed on fully configured and functioning equipment complete with interconnecting cables and interface loads. Levels are defined as **measured values in the test set-up**. Either the test level or the limit value has to be reached.

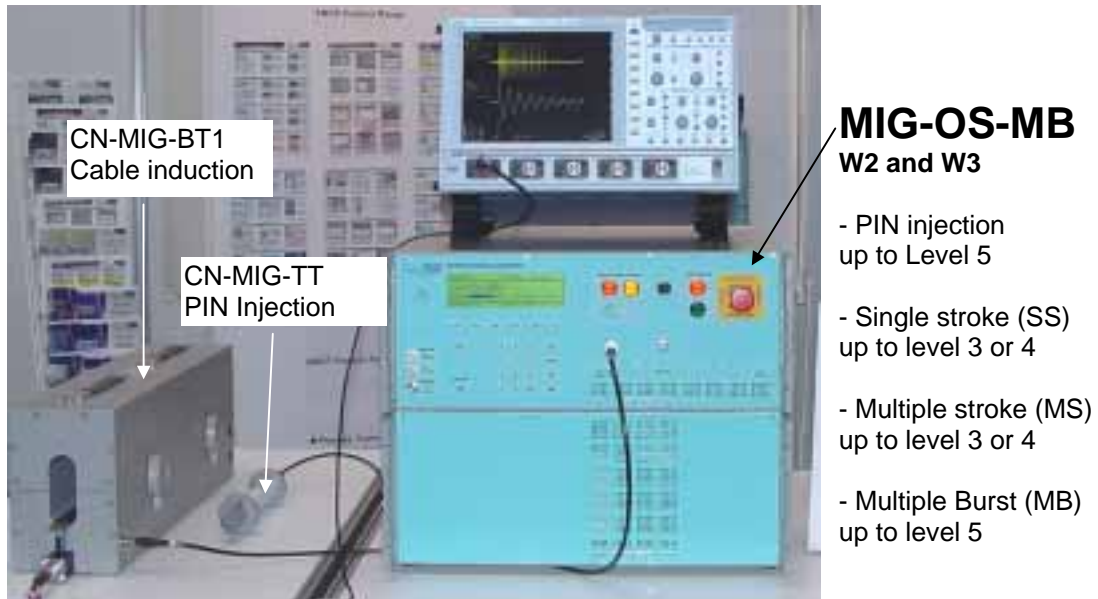
Prior to testing or at regular intervals (2 years) the waveshapes have to be verified (calibrated) in the calibration loop as defined in the EMC-PARTNER verification protocol.

Cable Induction : Waveforms 2 and 3 are injected using the cable induction method with the CN-BT, BT1 or CN-BT3.

The waveform is induced through the coupling clamp CN-MIG-BTx into interconnecting cables and power leads. Set the generator to the voltage or current according to the test level. In the test set-up measure the voltage at the calibration loop of the CN-MIG-BTx and the current in the cable bundle. Increase the generator output until the test level or the limit is reached.



2 EMC PARTNER MULTIPLE BURST TEST SYSTEM



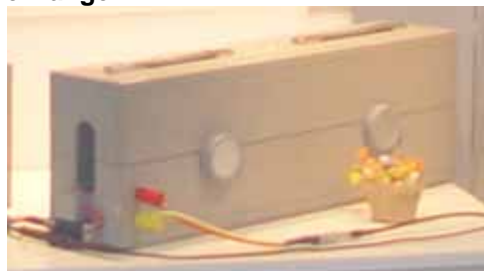
MIG-OS-MB W2 and W3

- PIN injection up to Level 5
- Single stroke (SS) up to level 3 or 4
- Multiple stroke (MS) up to level 3 or 4
- Multiple Burst (MB) up to level 5

Fig: MIG-OS-MB with standard accessories. The test guide is based on using the standard accessories CN-MIG-BT1 and CN-MIG-TT.

EMC PARTNER Coupler range:

CN-MIG-BT1



CN-MIG-BT1
aperture hole 3 x 7.5 cm
1" x 3"
Length 60 cm
V-monitoring
with 1 loop voltage
measurement

For cable bundle test up to level 5

CN-MIG-BT3



CN-MIG-BT3
aperture hole 7.7 x 7.7 cm
3" x 3"
Length 50 cm
V-monitoring
with 1 loop voltage
measurement

For cable bundle test up to level 5

CN-MIG-BT



CN-MIG-BT
aperture hole 3 x 7.5 cm
1" x 3"
Length 20 cm
V-monitoring
with 1 loop voltage
measurement

for cable bundle test up to Level 3

MIG-OS-MB-EXT

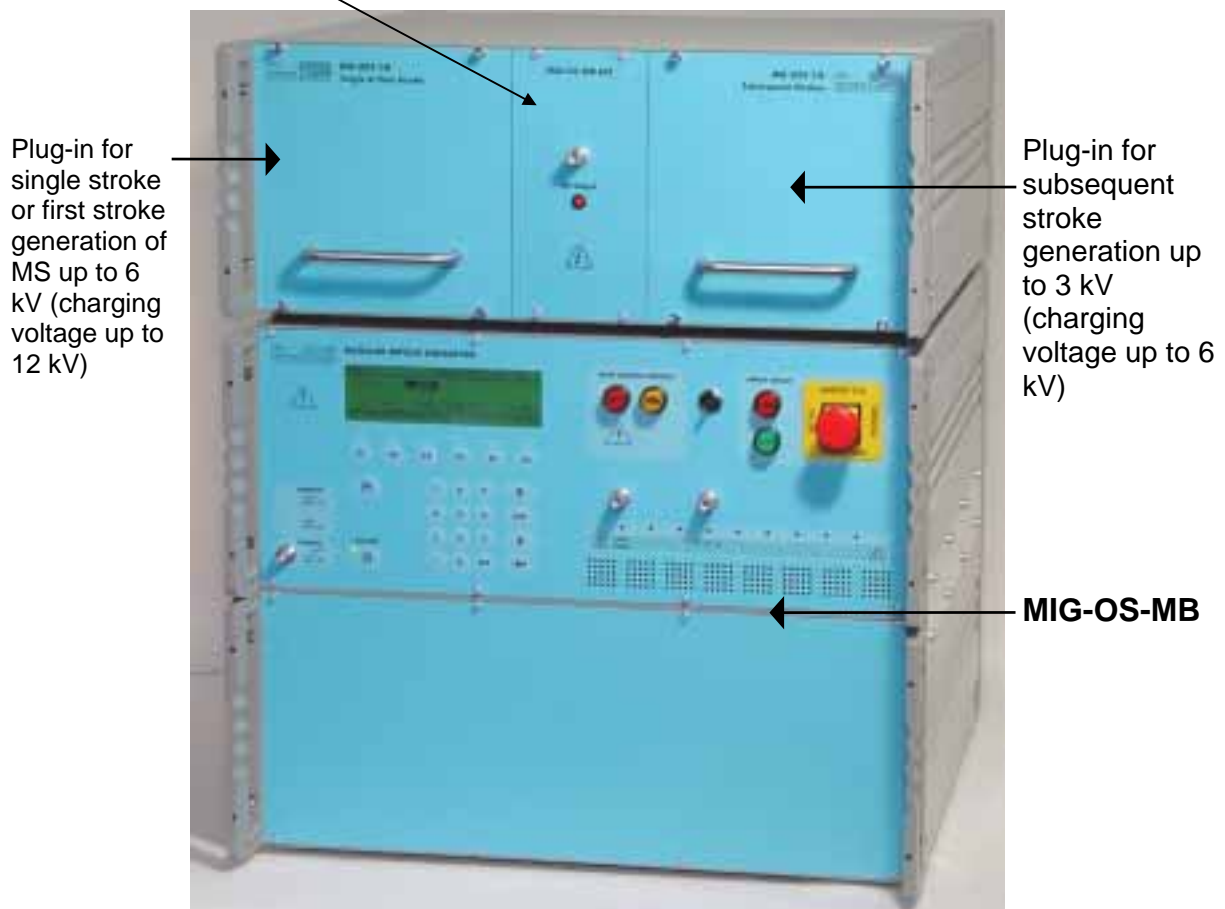


Fig: MIG-OS-MB with MIG-OS-MB-EXT

MIG-OS-MB-EXT application range, single stroke and multiple stroke:

- 1- Customised frequencies between 1 MHz and 10 MHz
- 2- Extension of the MIG-OS-MB, 0.1/6.4 μ s, 1 MHz and 10 MHz up to Level 5
- 3- Other waveforms and application on demand

3 PIN INJECTION TESTS, TABLE 22-2

Pin injection tests are primarily for damage assessment and involve the injection of transients directly into EUT interface circuits. Levels are defined as open circuit voltage or short circuit current without any load. In the test set-up the true values are given by the load.

Prior to testing or at regular intervals (2 years) the waveshapes have to be verified (calibrated) as defined in the EMC-PARTNER verification report. During the test no waveform measurements have to be performed.

Test-Procedure for Pin Injection :

The waveform is applied directly to the designated pins of the EUT connector, usually between each pin and case ground. The EUT is normally unpowered. Set the generator to the voltage or current according to the test level. Monitor the voltage waveform at the U-CRO output of the generator for signs of unexpected changes.

Apply a minimum of 10 pulses in each polarity.

Amplitude Tolerances : -0/+10%

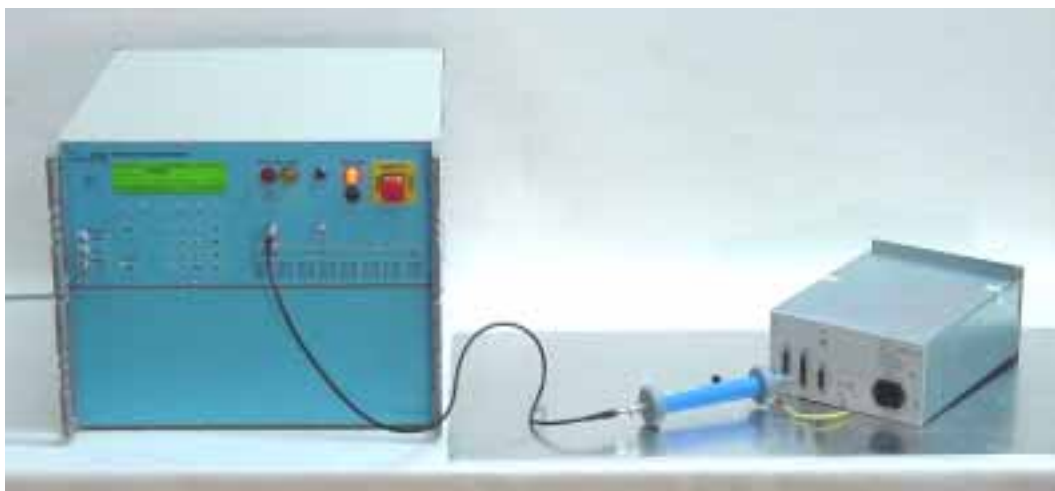
3.1 PIN: W3 1MHz and 10MHz

Pin-Injection 22-2

Equipment:	Generator :	MIG-OS-MB	EMC-PARTNER AG
	Injection :	Test-Tip: CN-MIG-TT	EMC-PARTNER AG
	Measurement :	---	

Test Set-up:

Connect the Test-Tip CN-MIG-TT using the 1 meter SHV cable to the generator and apply the pulses with the Test-Tip directly between the pins and the case ground. Set the generator to the nominal voltage (+10%).



Waveform 3: Pin 1MHz Single (25 ohm)

Level	V(oc) / I(sc)	Generator set-up MIG-OS-MB	
		Nominal Voltage	
1	100V/4A	100V	Waveshape : 3: Pin 1MHz Repetition : 6.0s Test-Time : 60s Trigger Mode : auto
2	250V/10A	250V	
3	600V/24A	600V	
4	1500V/60A	1500V	
5	3200V/128A	3200V	

Waveform 3: Pin 10MHz Single (25 ohm)

Level	V(oc) / I(sc)	Generator set-up MIG-OS-MB	
		Nominal Voltage	
1	100V/4A	100V	Waveshape : 3: Pin 10MHz Repetition : 6.0s Test-Time : 60s Trigger Mode : auto
2	250V/10A	250V	
3	600V/24A	600V	
4	1500V/60A	1500V	
5	3200V/128A	3200V	

4 CABLE BUNDLE TESTS, SINGLE STROKE, TABLE 22-3

Test-Procedure for cable bundle tests :

Waveform 2 and 3 are injected through the cable induction method. The waveform is induced using the coupling clamp CN-MIG-BTx into interconnecting cables and power leads. Set the generator to the voltage or current according to the test level. In the test set-up measure the voltage at the calibration loop of the CN-MIG-BTx and the current in the cable bundle. Increase the generator output until the test level or the limit is reached.

Apply a minimum of **10 pulses** in each polarity.

Amplitude Tolerances :: -0/+20%

4.1 CB-SS: W2 0.1/6.4µs, W3 1MHz and 10MHz

Equipment:	Generator :	MIG-OS-MB	EMC-PARTNER AG	
	Injection :	Coupling Clamp : CN-MIG-BT1	EMC-PARTNER AG	
	Measurement :	HV-probe :	4kV, 100MHz	e.g. Fluke PM9100/101
		Current probe :	I-Probe MB or 110A	EMC-PARTNER A Pearson

Test Set-up:

Connect the generator using the 1meter SHV cable to the coupling clamp CN-MIG-BTx. Insert the cable bundle into the coupling clamp. Set the voltage to the nominal value and run the generator. Increase the voltage with the up/down switch until the Test-Voltage is reached.

Measure the test-voltage with a HV-probe at the monitor loop of the coupling clamp CN-MIG-BTx.

For the lower levels you have to monitor the current in the cable bundle with a current probe to ensure current limits are not exceeded.



Waveform 3: CB 1MHz Single

Cable induction

Level	Test Voltage	Limit Current	Generator set-up	MIG-OS-MB
			Nominal Voltage	
1	100V	20A	100V	Waveshape : 3: CB 1MHz SS Repetition : 6.0s Test-Time : 60s Trigger Mode : auto
2	250V	50A	250V	
3	600V	120A	600V	
4	1500V	300A	1500V	
[5]	3200V	640A	3200V	

- Level 1, 2 and 3 can be reached for every load. Monitor the current to ensure the limit-current is not exceeded. To reach the test-voltage without exceeding the limit current, the cable bundle has to be longer than 1.5 meter and about 10 cm above ground reference plane.
- Level 4 test voltage is reached on cable bundles longer than about 5 meters.
- With MIG-OS-MB level 5 test voltage can only be reached for cable bundle inductances greater than 47uH.
- **With MIG-OS-MB-EXT and the NW-WF3-1M-FS** the level 5 test voltage can be reached for inductances greater than 5 µH. Calculation of self inductance see chapter 6.

Waveform 3: CB 10MHz Single

Cable induction

Level	Test Voltage	Limit Current	Generator set-up	MIG-OS-MB
			Nominal Voltage	
1	100V	20A	100V	Waveshape : 3: CB 10MHz SS Repetition : 6.0s Test-Time : 60s Trigger Mode : auto
2	250V	50A	250V	
3	600V	120A	600V	
4	1500V	300A	1500V	
[5]	3200V	640A	3200V	

- Level 1, 2, 3 and 4 can be reached for every load. The limit current is never reached, even not for very short low impedance cables.
- With MIG-OS-MB level 5 is reached on cable bundles longer than about 4 meters.
- **With MIG-OS-MB-EXT and the NW-WF3-10M-FS** the level 5 test voltage can be reached for inductances greater about 1 µH. For a calculation of self inductance see chapter 6.

Waveform 2: CB 0.1/6.4us Single

Cable induction

Level	Test Voltage	Limit Current	Generator set-up	MIG-OS-MB
			Nominal Voltage	
1	50V	100A	50V	Waveshape : 2: CB 0.1/6.4 SS Repetition : 6.0s Test-Time : 60s Trigger Mode : auto
2	125V	250A	125V	
3	300V	600A	300V	
4	750V	1500A	750V	
[5]	1600V	3200A	1600V	

- Level 1, 2 and 3 can be reached for every load. The limit current is never reached, even in very short low impedance cables.
- Level 4 is reached on cable bundles longer than about 3 meters.
- With MIG-OS-MB level 5 can only be reached for cable bundles greater 50uH. For a calculation of self inductance see chapter 6..
- **With MIG-OS-MB-EXT and the NW-WF2** the level 5 test voltage can be reached for inductance greater than about 3 µH. For a calculation of self inductance see chapter 6.

Waveform 2 is used only for unshielded cables.

4.2 Cable Bundle Tests, Multiple Stroke, Table 22-4

22-4 Multiple Stroke. The multiple stroke event includes a first full level transient followed by 13 transients on half level. The transients are randomly distributed over a period of up to 1.5s with a spacing between 10ms and 200ms. This pattern is stored as „**Pattern 12**“ in the pattern generator. For other patterns see manual.

Test Procedure, Test-Setup and Calibration are the same as for Single Stroke. Apply a minimum of 10 multiple stroke events in each polarity.

Amplitude Tolerances : First Stroke : -0/+20% , Subsequent : -0/+50%

4.3 CB-MS: W2 0.1/6.4µs, W3 1MHz and 10 MHz:

Equipment:	Generator :	MIG-OS-MB	EMC-PARTNER AG	
	Injection :	Coupling clamp : CN-MIG-BT1	EMC-PARTNER AG	
	Measurement :	HV-probe :	4kV, 100MHz	e.g. Fluke PM9100/101
		Current probe :	I-Probe MB or 110A	EMC-PARTNER A Pearson

Test Set-up:

Connect the generator using the 1meter SHV cable to the coupling clamp CN-MIG-BTx. Insert the cable bundle into the coupling clamp. Set the voltage to the nominal value and run the generator. Increase the voltage with the up/down switch until the Test-Voltage is reached.

Measure the test-voltage with a HV-probe in the monitor loop of the coupling clamp CN-MIG-BTx.

For the lower levels you have to monitor the current in the cable bundle with a current probe to ensure the limit current is not exceeded.



Waveform 3: CB 1MHz Multiple-Stroke

First Stroke is 100%, Subsequent Strokes are 50%

Level	Test Voltage		Limit Current		Generator set-up	MIG-OS-MB
	First	Subs.	First	Subs.	Nominal Voltage	
1	100V	50V	20A	10A	100V	Waveshape : 3: CB 1MHz MS
2	250V	125V	50A	25A	250V	Attenuation : 1/2 (Subsequent)
3	600V	300V	120A	60A	600V	Pattern Nbr. : 12
4	1500V	750V	300A	150A	1500V	Repetition : 10.0s
[5]	3200V	1600V	640A	320A	3200V	Test-Time : 100s

- Level 1, 2 and 3 can be reached for every load. Monitor the current to ensure the limit-current is not exceeded. To reach the test-voltage without exceeding the limit current, the cable bundle has to be longer than about 1.5 meter.
- Level 4 is reached on cable bundles longer than about 5 meters.
- With MIG-OS-MB level 5 can only be reached for cable bundles with inductances greater than 47uH. For a calculation of self inductance see chapter 6.
- **With MIG-OS-MB-EXT and the NW-WF3-10M-FS and NW-WF3-10M-SS** the level 5 test voltage can be reached for inductance greater than about 5 µH. Calculation of self inductance see chapter 6.

Waveform 3: CB 10MHz Multiple-Stroke First Stroke is 100%, Subsequent Strokes are 50%

Level	Test Voltage		Limit Current		Generator set-up	MIG-OS-MB
	First	Subs.	First	Subs.	Nominal Voltage	
1	100V	50V	20A	10A	100V	Waveshape : 3: CB 10MHz MS Attenuation : 1/2 (Subsequent)
2	250V	125V	50A	25A	250V	Pattern Nbr. : 12
3	600V	300V	120A	60A	600V	Repetition : 10.0s
4	1500V	750V	300A	150A	1500V	Test-Time : 100s
[5]	3200V	1600V	640A	320A	3200V	

- Level 1, 2, 3 and 4 can be reached for every load. The limit current is never reached, even in very short low impedance cables.
- With MIG-OS-MB level 5 is reached on cable bundles longer than about 4 meters.
- **With MIG-OS-MB-EXT and the NW-WF3-10M** the level 5 test voltage can be reached for inductances greater than about 1 µH. For a calculation of self inductance see chapter 6.

Waveform 2: CB 0.1/6.4us Multiple-Stroke First Stroke is 100%, Subsequent Strokes are 50%

Level	Test Voltage		Limit Current		Generator set-up	MIG-OS-MB
	First	Subs.	First	Subs.	Nominal Voltage	
1	50V	25V	50A	25A	50V	Waveshape : 2: CB 0.1/6.4us Attenuation : 1/2 (Subsequent)
2	125V	62.5V	125A	62.5A	125V	Pattern Nbr. : 12
3	300V	150V	300A	150A	300V	Repetition : 10.0s
4	750V	375V	750A	375A	750V	Test-Time : 100s
[5]	1600V	800V	1600A	800A	1600V	

- Level 1, 2 and 3 can be reached for every load. The limit current is never reached, even in very short low impedance cables.
- Level 4 is reached on cable bundles longer than about 3 meters.
- With MIG-OS-MB level 5 can only be reached for cable bundles with inductances greater than 50uH. For a calculation of self inductance see chapter 6.
- **With MIG-OS-MB-EXT and the NW-WF2** the level 5 test voltage can be reached for inductance greater than about 3 µH. For a calculation of self inductance see chapter 6..

• **Waveform 2 is used only for unshielded cables.**

5 CABLE BUNDLE TESTS, MULTIPLE BURST, TABLE 22-5

22-5 Multiple Burst

The multiple burst event include 3 bursts of 20 pulses each, all at the same level. The pulses are randomly distributed. The pulse separation within each burst has to be between 50us and 1000us, and the burst separation between 30ms and 300ms.

This pattern is stored as „**Pattern 11**“ in the pattern generator. For other patterns see manual.

Apply the burst event every 3 second for at least 5 minutes in each polarity.

Amplitude Tolerances : -0/+20% , over all pulses :

5.1 CB-MB: W3H : 1MHz and 10MHz

22-5 Cable Bundles, Multiple Burst

Equipment:	Generator :	MIG-OS-MB	EMC-PARTNER AG
	Injection :	Coupling clamp : CN-MIG-BT1 or 3	EMC-PARTNER AG
	Measurement :	HV-probe : 4kV, 100MHz	e.g. Fluke PM9100/101
		Current probe : I-Probe MB or 110A	EMC-PARTNER A Pearson

Test Set-up:

Connect the generator using the 1meter SHV cable to the coupling clamp CN-MIG-BTx. Insert the cable bundle into the coupling clamp. Set the voltage to the nominal value and run the generator. Increase the voltage with the up/down switch until the test-voltage is reached. Measure the test-voltage with a HV-probe at the monitor loop of the coupling clamp CN-MIG-BTx. Monitor the current in the cable bundle with a current probe to ensure the limit current is not exceeded.



Waveform 3H: CB 1MHz Multiple Burst

Level	Test Voltage	Limit Current	Generator set-up
			Nominal Voltage
1	60V	1A	60V
2	150V	2.5A	150V
3	360V	6A	360V
4	900V	15A	900V
5	1920V	32A	1920V

Waveshape :	3: CB 1MHz MB
Pattern Nbr. :	11
Repetition :	3.0s
Test-Time :	300s
Trigger Mode :	auto

- Level 1, 2, 3, 4 and 5 can be reached for every load.
Monitor the current to ensure the limit current is not exceeded. Usually the current limit is reached before the test-voltage even for very long cable bundles (>10m)

Waveform 3H: CB 10MHz Multiple Burst

Level	Test Voltage	Limit Current	Generator set-up	
			Nominal Voltage	Waveshape : 3: CB 10MHz MB
1	60V	1A	60V	Pattern Nbr. : 11
2	150V	2.5A	150V	Repetition : 3.0s
3	360V	6A	360V	Test-Time : 300s
4	900V	15A	900V	Trigger Mode : auto
5	1920V	32A	1920V	

- Level 1, 2, 3, 4 and 5 can be reached for every load.
 Monitor the current to ensure the limit current is not exceeded. The current limit is reached before the test-voltage even for very long cable bundles (>10m)

5.2 CB-MB: W6H : 0.224/4us

Waveform 6H is used only for short, fully shielded cable bundles.

22-5 Cable Bundles, Multiple Burst

Equipment: Generator : MIG-OS-MB, MIG-OS-MB-EXT with NW-WF-6H EMC-PARTNER AG
 Injection : Coupling clamp : CN-MIG-BT1 or 3 EMC-PARTNER AG
 Measurement : HV-probe : 4kV, 100MHz e.g. Fluke PM9100/101
 Current probe : **I-Probe MB** EMC-PARTNER A
 or 110A Pearson



Fig: MIG-OS-MB with MIG-OS-MB-EXT and NW-WF-6H

Test Set-up:

Connect the generator using the 1meter SHV cable to the coupling clamp CN-MIG-BT1. Insert the cable bundle into the coupling clamp. Set the current to the nominal value and run the generator. Increase the current with the up/down switch until the test-current is reached. Measure the test-current with a current probe in the cable bundle. Monitor the voltage at the monitor loop of the coupling clamp CN-MIG-BT1 with a HV-probe to ensure the limit voltage is not exceeded.

Waveform 6H : CB 0.224/4us Multiple Burst

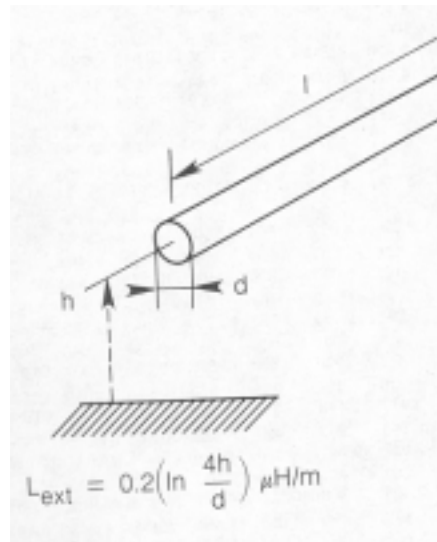
Level	Test Current	Limit Voltage	Generator set-up	
			Nominal Current	Waveshape : 0.224/4us M-Burst
1	5A	70V	5A	Pattern Nbr. : 11
2	12.5A	180V	13A	Coupling via CDN: on
3	30A	430V	30A	Repetition : 3.0s
4	75A	1080V	75A	Test-Time : 300s
5	160A	2290V	160A	Trigger Mode : auto

- Level 1, 2, 3, 4 and 5 can be reached for every load.
Monitor the voltage at the monitor loop to ensure the limit voltage is not exceeded.
- **Maximum 3 x 20 pulses** per pattern possible within 2 seconds

6 APPROXIMATION OF SELF INDUCTANCE

The self inductance can be calculated for different cable layouts as showed below. With the calculated self inductance the maximum level can be found where the MIG-OS-MB generator or the MIG-OS-MB with EXT can be used.

6.1 Wire above ground plane



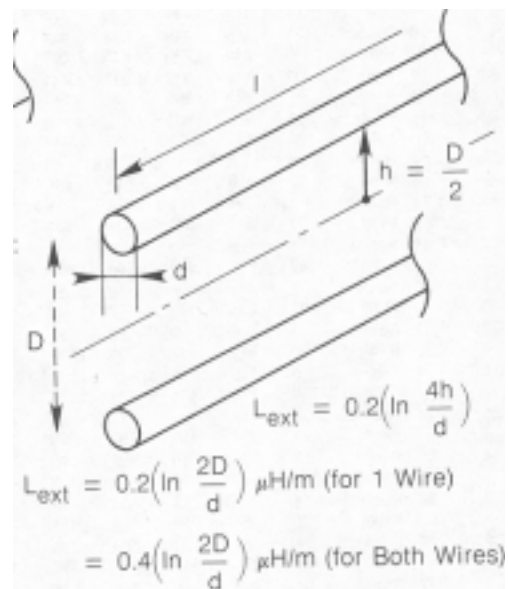
Example:

Height $h = 0.1\text{m}$

diameter of the wire $d = 2.5\text{ mm}$

L_{ext.} = 1.02 μH

6.2 Two round wires



Example:

One wire

Height $h = D/2 = 0.05\text{m}$

diameter of the wire $d = 2.5\text{ mm}$

L_{ext.} = 0.87 μH

Both wires

Height $h = D/2 = 0.05\text{m}$; $D = 0.1\text{m}$

diameter of the wire $d = 2.5\text{ mm}$

L_{ext.} = 1.75 μH

6.3 Rectangular ground straps

$$L = 0.002l \left[\ln \frac{2l}{b+c} + 0.5 + 0.2235 \frac{b+c}{l} \right] \mu\text{H}$$

where,

b = width of the strap
 c = thickness of the strap
 l = length of the strap in centimeters

Table 2.5—Inductance of Various Straps

Width b in cm	Thickness c in mm	L, in μH for:		
		l = 15 cm	l = 30 cm	l = 100 cm
1	0.2	0.115	0.30	1.15
	1	0.1	0.27	1.11
	2	0.08	0.22	0.8
2.5	0.2	0.09	0.22	1
	1	0.08	0.2	0.90
	2	0.07	0.17	0.80
5	0.2	0.07	0.19	0.85
	1	0.066	0.18	0.83
	2	0.06	0.16	0.75

Observe that the inductance does decrease with increasing width and increasing with increasing length.

6.4 SAE ARP5415 Approximation

The short circuit current on the wire bundle or shield is:

$$i = I/L \int (v dt) \approx V t / L$$

i = short circuit current, in Amperes

L = the self inductance of the wire bundle (typically 0.5 μH per meter times the length of the bundle)

t = time, in seconds

V = in volts

The voltage on a shielded core wire where the shield has a 360° connection to the backshell is:

$$v \approx iR$$

If the shield is terminated in pigtails then an additional voltage should be included as:

$$V_p = L di/dt$$

where:

L = the total inductance of all pigtails (typically 1 nH per millimetre times the total length of pigtails)

di/dt = the peak current rate of rise

Rate of rise $\approx I_{max} / t_{rise}$

W1 level SS = 3200 / 6.4 10^{-6} = 500 10^6 A/seconds

W1 level SS = 3200 / 0.1 10^{-6} = 32 10^9 A/seconds

Example: W2 0.1/6.4 μs L= 0.5 μH

V = 32 10^9 0.5 10^{-6} = 16 kV

Example: W1 6.4/70 μs L= 0.5 μH

V = 500 10^6 0.5 10^{-6} = 250 V

6.5 Generator output voltage approximation for waveform W3

The minimum cable length can be not shorter than the coupler e.g. CN-MIG-BT1 60 cm

Example W3 1MHz Level 5 single wire

$$V = 2\pi f \times L I = 6.28 \times 10^6 \times 0.9 \times 10^{-6} \times 640A = 3.6 \text{ kV}$$

Example W3 1MHz Level 5 cable bundle

$$V = 2\pi f \times L I = 6.28 \times 10^6 \times 0.9 \times 10^{-6} \times 640A = 2 \text{ kV}$$

Example W3 10 MHz Level 5 cable bundles

$$V = 2\pi f \times L I = 6.28 \times 10^7 \times 0.5 \times 10^{-6} \times 640A = 20 \text{ kV !!!}$$

The test voltage of 3200 V will be reached before the current limit

