

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

In accordance with DO160



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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

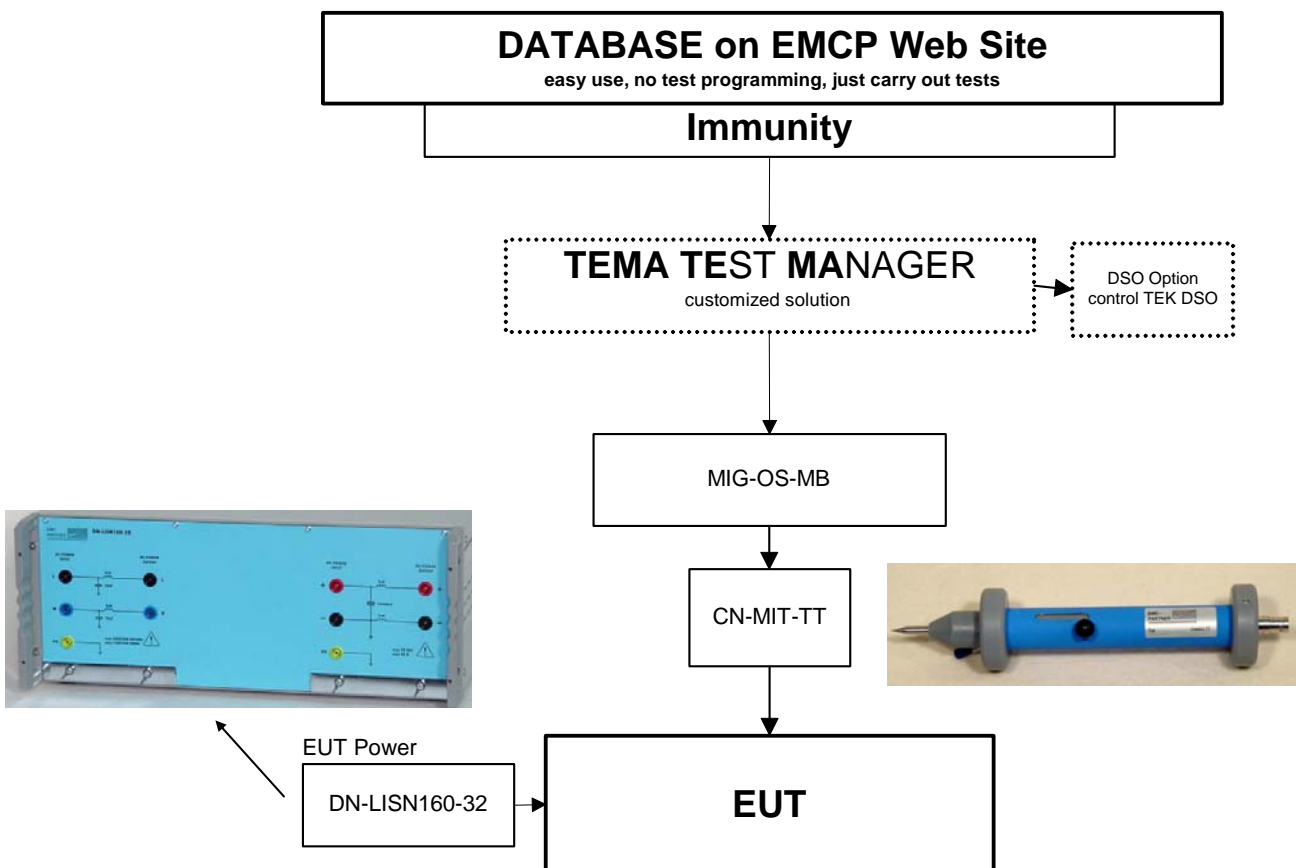
Pin injection tests are primarily for damage assessment and involve the injection of transients directly into EUT interface circuits. Levels are defined as open circuit voltage or short circuit current without any load. In the test set-up the true values of voltage or current are given by the load.

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 only waveform amplitude 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

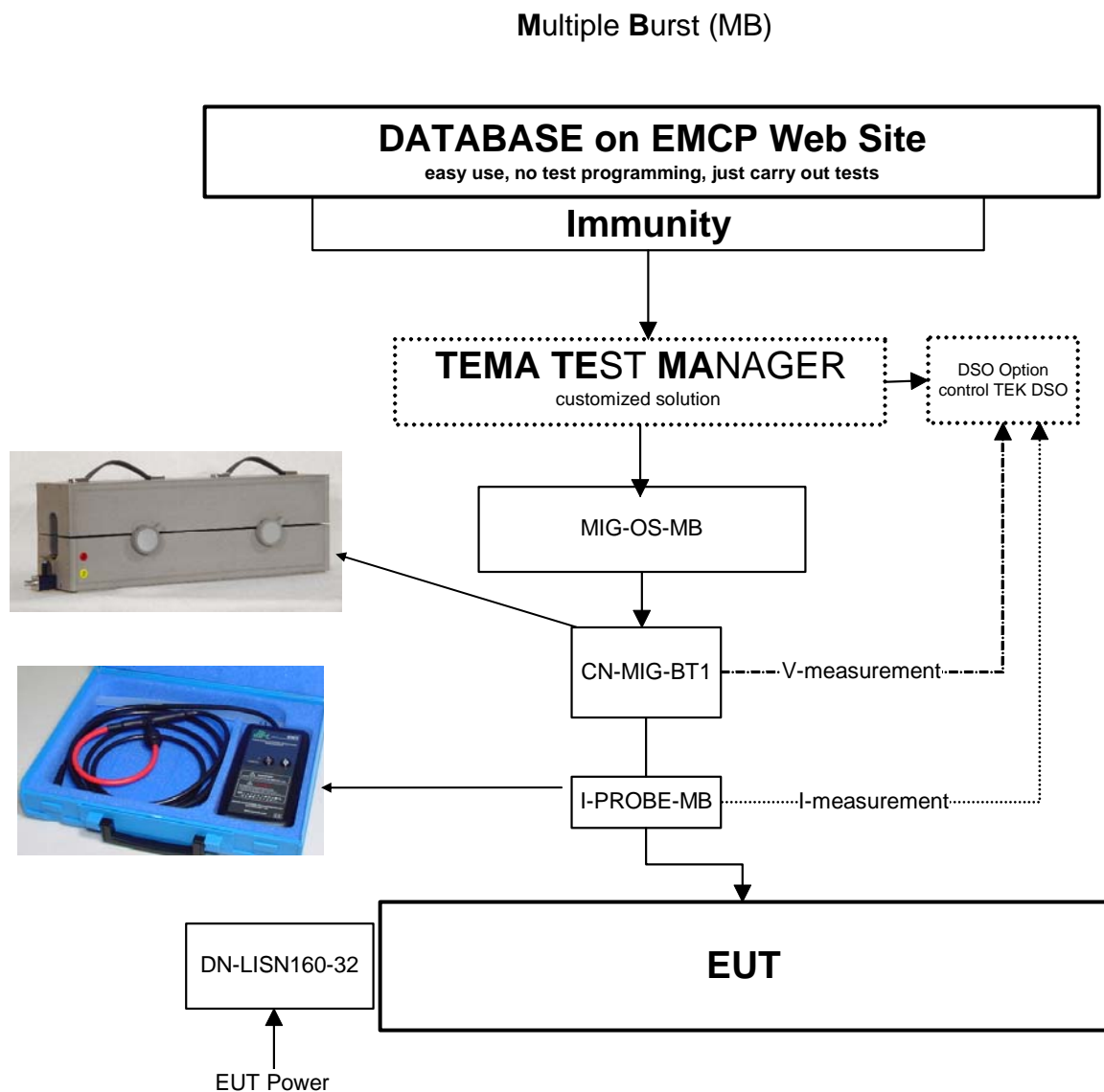
Cable bundle testing is a technique where transients are applied by **cable induction or ground injection**.

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.

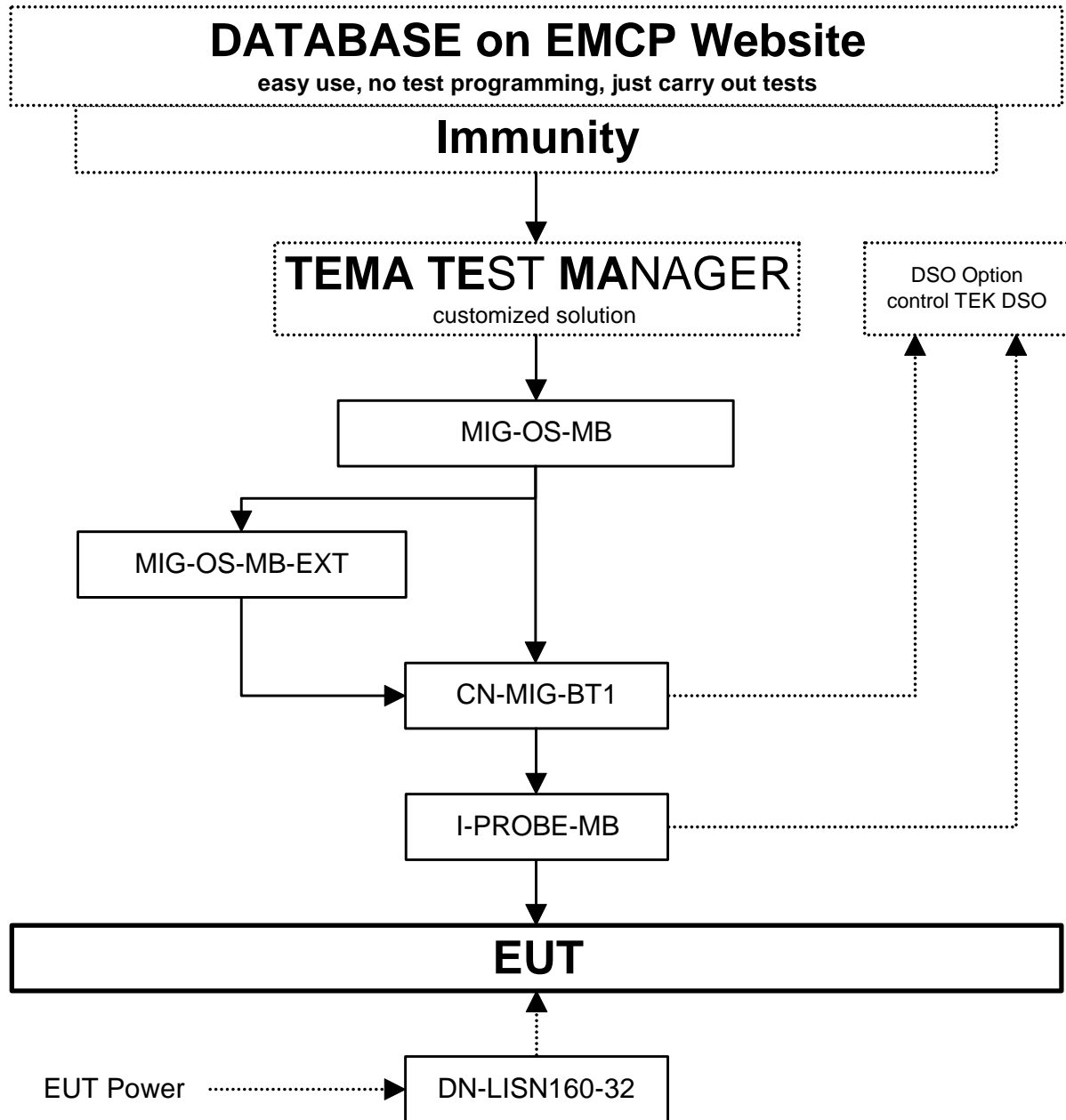
Prior to testing or at regular intervals ( 2 years ) the waveshapes have to be verified (calibrated) in the calibration loop as defined in the EMC-PARTNER verification protocol.

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

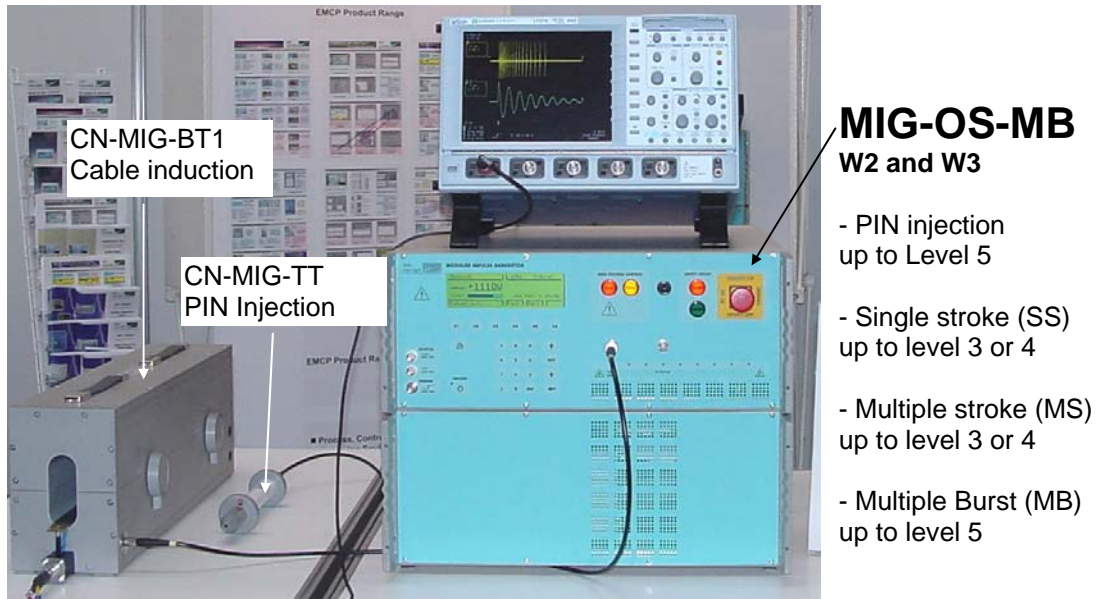


## Single Stroke (SS) & Multiple Stroke (MS)



**Ground Injection :** Waveshape 2 and 3 can also be injected using the ground injection method. The waveform is applied between the EUT case and the local ground plane after the EUT has been isolated from the local ground plane. The injected waveform is forced onto cable shields and any other return path to the local ground plane. Set the generator to the voltage or current according to the test level. In the test set-up measure the voltage between EUT and local ground plane and the current in the cables. Increase the generator level 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-BTx 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

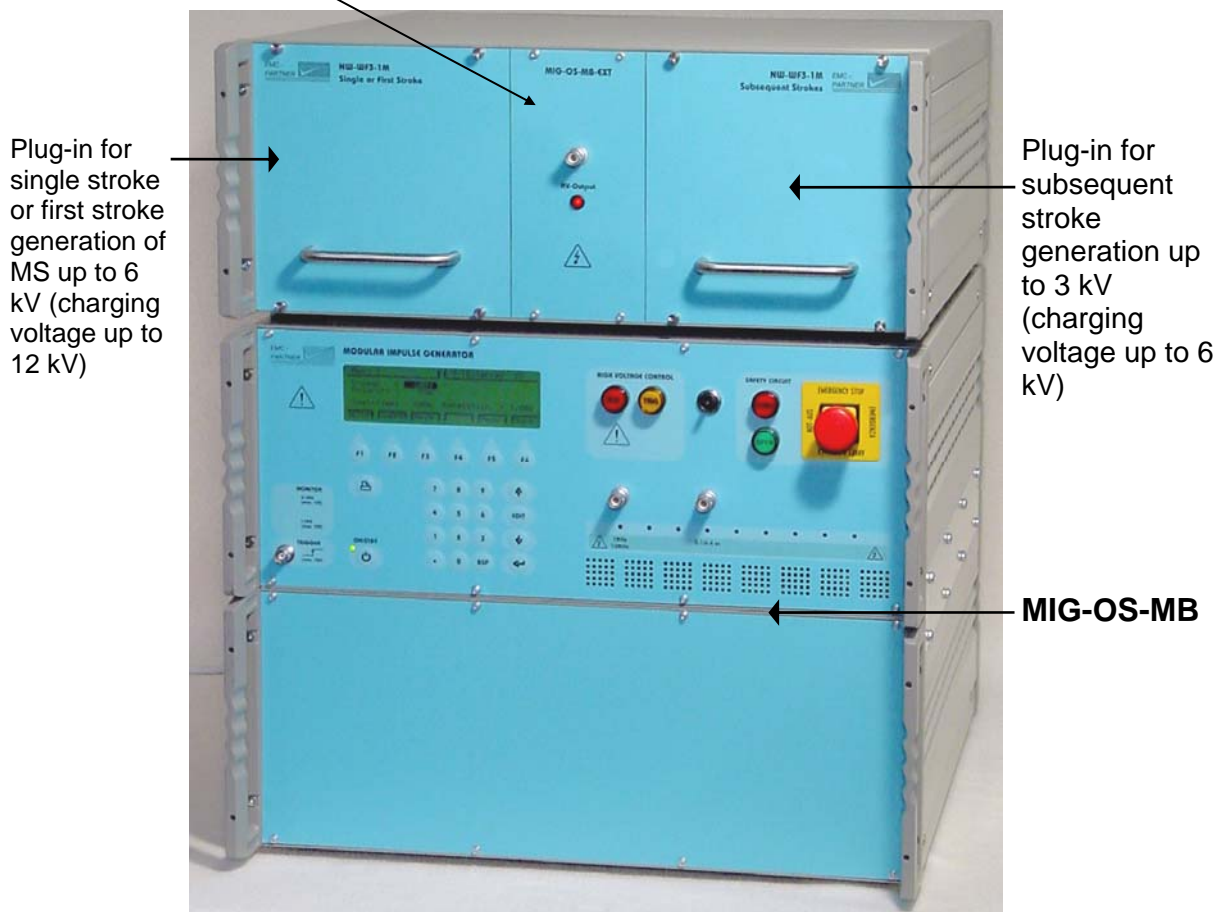


Fig: MIG-OS-MB with MIG-OS-MB-EXT

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  $\mu$ s, 1 MHz and 10 MHz up to Level 5
- 3- Addition of waveform 6H
- 4- 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%



To prevent possible damage to the MIG-OS-MB generator during tests on powered pins, an AC/DC decoupling device **MUST** be fitted between the generator and CN-MIG-TT. This is provided as part of the standard accessories with MIG-OS-MB.



### 3.1 PIN: W3 1MHz

#### 3.1.1 PIN W3 1MHz Level 1 - 3

#### Pin-Injection 22-2

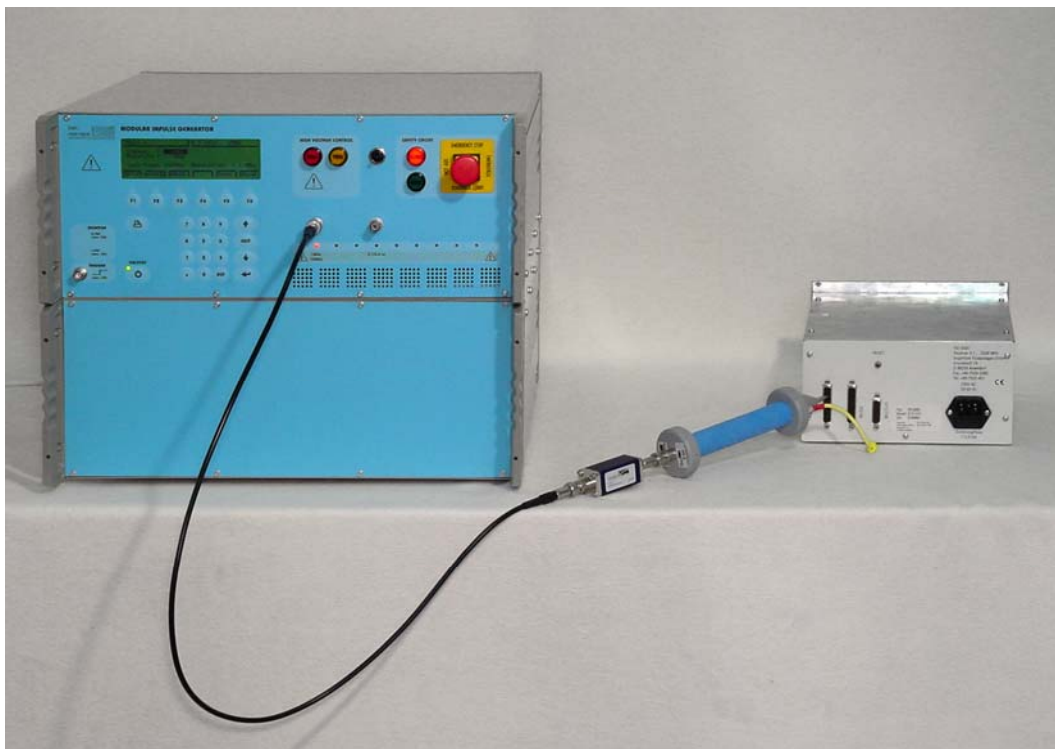
**Equipment:** Generator : MIG-OS-MB EMC-PARTNER AG  
 Injection Test-Tip: CN-MIG-TT + AC/DC decoupler EMC-PARTNER AG

#### Test Set-up

Connect the Test-Tip CN-MIG-TT and AC/DC decoupler 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 ( Level 1 to 3 )

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



### 3.1.2 PIN W3 1MHz Level 4 - 5

### Pin-Injection 22-2

**Equipment:** Generator : MIG-OS-MB + MIG-OS-MB-EXT EMC-PARTNER AG  
 Injection Test-Tip: CN-MIG-TT + CN-MIG-BT EMC-PARTNER AG  
 + AC/DC decoupler Level 4 & 5

#### Test Set-up

Connect the MIG-OS-MB-EXT using the 1 meter SHV cable to the CN-MIG-BT **COIL 1** input. Connect the test-Tip CN-MIG-TT and AC/DC decoupler Level 4 & 5 using a 1 meter SHV cable to the 1 turn secondary loop on CN-MIG-BT 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 ( Level 4 & 5 )

Level	V(oc) / I(sc)	Generator set-up	MIG-OS-MB + MIG-OS-MB-EXT
		Nominal Voltage	
			Waveshape : 3: Pin 1MHz
			Repetition : 6.0s
			Test-Time : 60s
4	1500V/60A <sup>1)</sup>	1500V	Trigger Mode : auto
5	3200V/128A <sup>1)</sup>	3200V	

1) For maximum current see calibration report of EMCP.



Testing for level 4 and 5 should be carried out using the MIG-OS-MB-EXT together with NW-WF3 1M module. In this case, the AC DC Decoupler Level 4 & 5 must be used.



## 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 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%



**When operating CN-MIG-BTx couplers on cable bundles containing power supply lines, pay attention to section 7.3 for current limitations**

### 4.1 Cable Bundle-Single Stroke: WF2 0.1/6.4μs

#### 4.1.1 SS WF2 Level 1 - 3

<b>Equipment:</b>	Generator :	MIG-OS-MB	EMC-PARTNER AG
	Injection :	Coupling Clamp : CN-MIG-BT, CN-MIG-BT1 or CN-MIG-BT3	EMC-PARTNER AG
	Measurement :	HV-probe : 4kV, 100MHz Current probe : <b>I-Probe MB-P1</b> or similar	e.g. Fluke PM9100/101 EMC-PARTNER A

### 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 current limits are not exceeded.



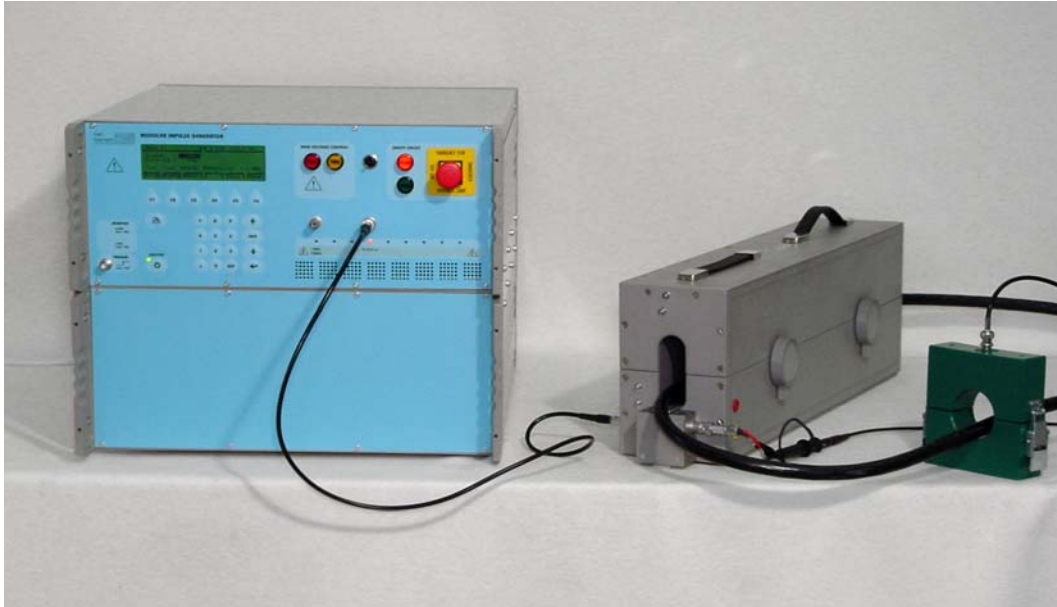
**Select coupling via BT3 ON or OFF as appropriate**

### Waveform 2: CB 0.1/6.4us Single stroke

### Cable induction

Level	Test Voltage	Limit Current	Generator set-up Nominal Voltage	MIG-OS-MB
1	50V	100A	50V	Waveshape : 2: CB .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. 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.



#### 4.1.2 SS WF2 Level 4 - 5

<b>Equipment:</b>	Generator :	MIG-OS-MB + MIG-OS-MB-EXT + NW-WF2-FS	EMC-PARTNER AG
	Injection :	Coupling Clamp : CN-MIG-BT1 or CN-MIG-BT3	EMC-PARTNER AG
	Measurement :	HV-probe : 4kV, 100MHz	e.g. Fluke PM9100/101
		Current probe : <b>I-Probe MB-P1</b> or similar	EMC-PARTNER A

#### Test Set-up:

Connect the MIG-OS-MB-EXT 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 output voltage 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 current limits are not exceeded.



**Select coupling via BT3 ON or OFF as appropriate**

#### Waveform 2: CB 0.1/6.4us Single

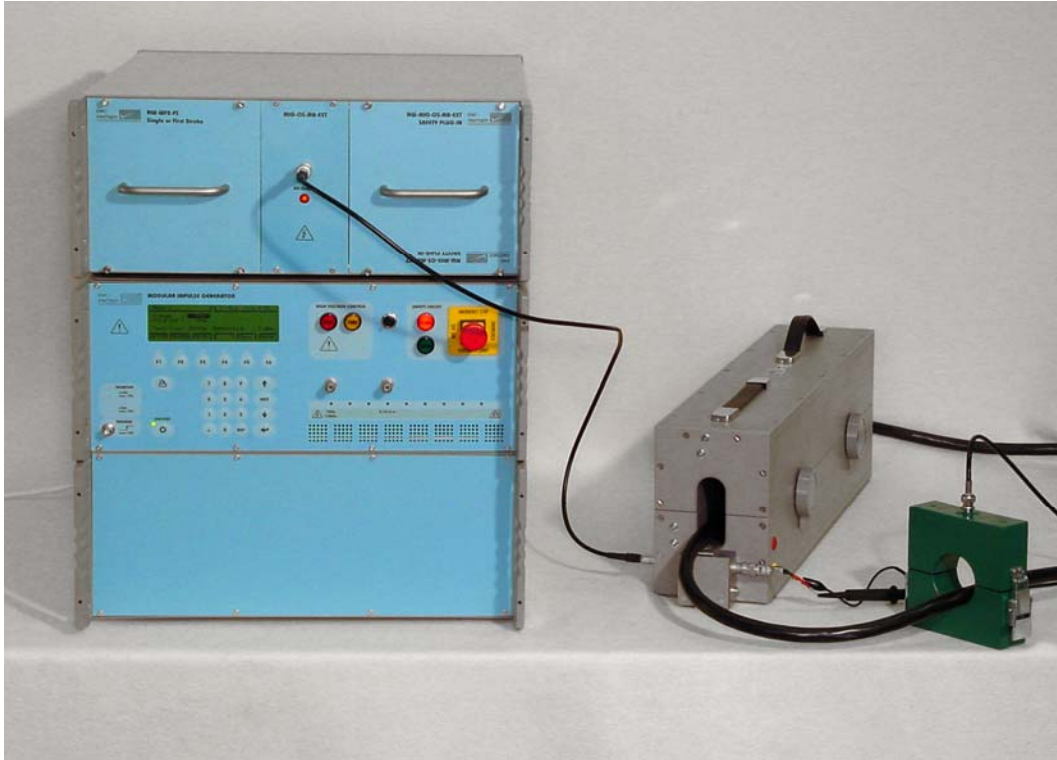
#### Cable induction

Level	Test Voltage	Limit Current	Generator set-up	MIG-OS-MB-EXT
			Nominal Voltage	
1				Waveshape : 2: EXT .1/6.4 SS
2				Repetition : 6.0s
3				Test-Time : 60s
4	750V	1500A	750V	Trigger Mode : auto
[ 5 ]	1600V	3200A	1600V	

Maximum open circuit voltage is 5000V and short circuit current is 1,666A

- **With MIG-OS-MB-EXT and the NW-WF2** the level 5 test voltage can be reached for inductance greater than about 3  $\mu$ H. For a calculation of self inductance see chapter 6.

Waveform 2 is used only for unshielded cables.



To maintain the WF2 pulse duration within the DO160 tolerances, an air gap spacer must be placed in the CN-MIG-BT1 coupler as shown below.



## 4.2 Cable Bundle-Single Stroke: WF3 1MHz

### 4.2.1 SS WF3 1MHz Level 1 - 3

<b>Equipment:</b>	Generator :	MIG-OS-MB	EMC-PARTNER AG
	Injection :	Coupling Clamp : CN-MIG-BT, CN-MIG-BT1 or CN-MIG-BT3	EMC-PARTNER AG
	Measurement :	HV-probe : 4kV, 100MHz	e.g. Fluke PM9100/101
		Current probe : <b>I-Probe MB-P1</b> or similar	EMC-PARTNER AG

#### 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.



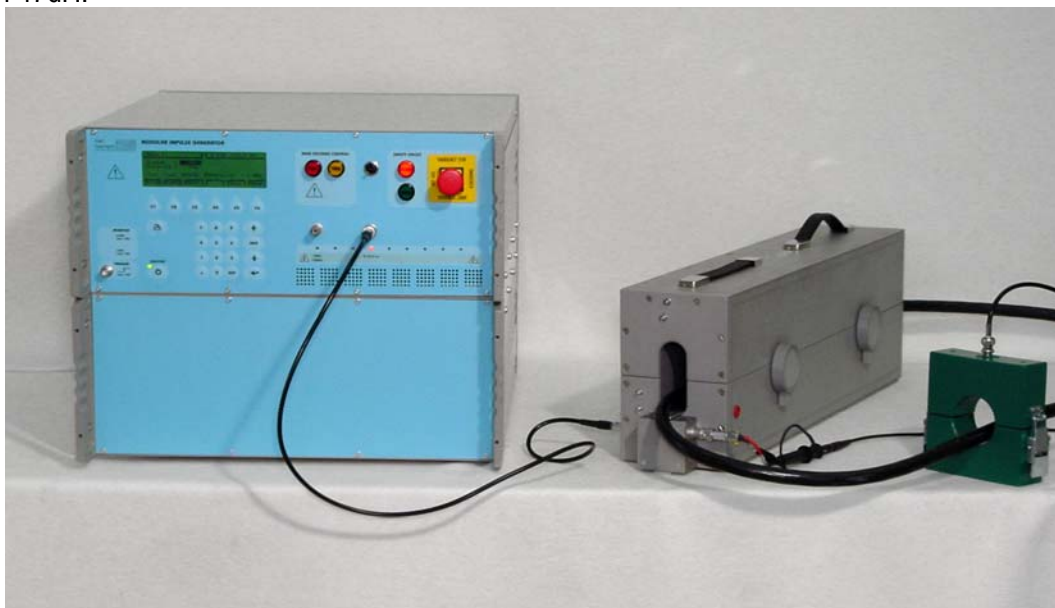
**Select coupling via BT3 ON or OFF as appropriate**

**Waveform 3: CB 1MHz Single stroke**

**Cable induction**

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



#### 4.2.2 SS WF3 1MHz Level 4 - 5

<b>Equipment:</b>	Generator :	MIG-OS-MB + MIG-OS-MB-EXT + NW-W31M-FS	EMC-PARTNER AG
	Injection :	Coupling Clamp : CN-MIG-BT1 or CN-MIG-BT3	EMC-PARTNER AG
	Measurement :	HV-probe : 4kV, 100MHz Current probe : <b>I-Probe MB-P1</b> or similar	e.g. Fluke PM9100/101 EMC-PARTNER AG

#### Test Set-up:

Connect the MIG-OS-MB-EXT 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 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 current limits are not exceeded.



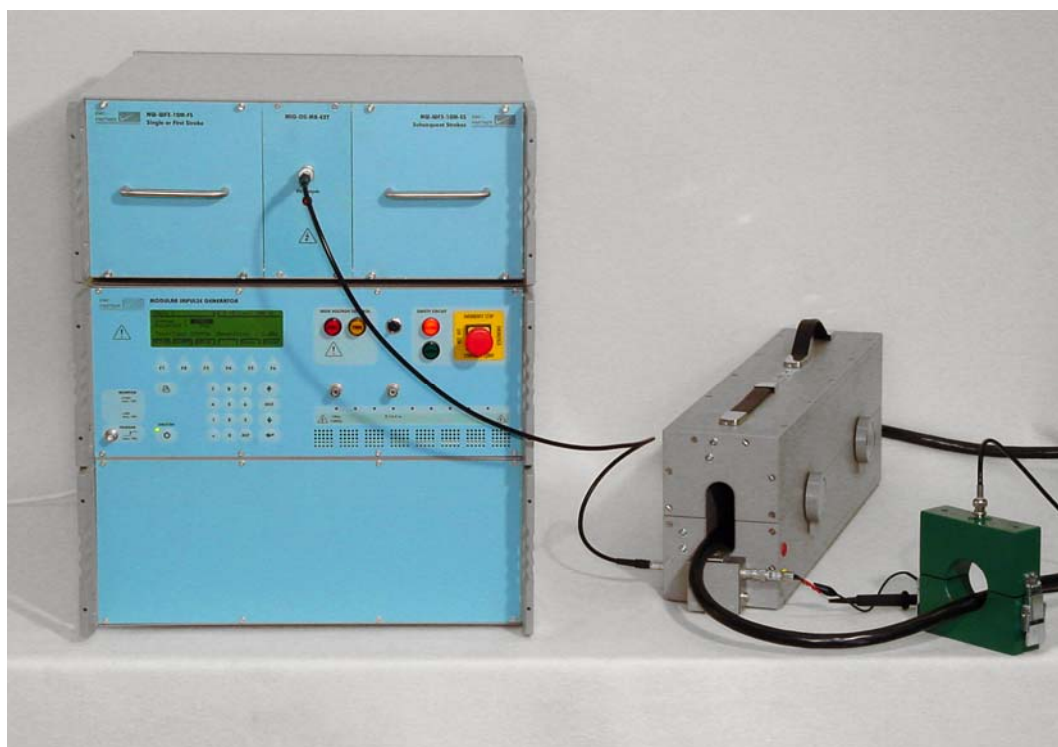
**Select coupling via BT3 ON or OFF as appropriate**

#### Waveform 3: CB 1MHz Single stroke

#### Cable induction

Level	Test Voltage	Limit Current	Generator set-up Nominal Voltage	MIG-OS-MB-EXT
1				Waveshape : 3: Extern 1MHz SS
2				Repetition : 6.0s
3				Test-Time : 60s
4	1500V	300A	1500V	Trigger Mode : auto
5	3200V	640A	3200V	

- With **MIG-OS-MB-EXT** and the **NW-WF3-1M-FS** the level 5 test voltage can be reached for inductances greater about 1  $\mu$ H. For a calculation of self inductance see chapter 6.



### 4.3 CB-SS: WF3 10MHz

#### 4.3.1 SS WF3 10MHz Level 1 - 3

<b>Equipment:</b>	Generator :	MIG-OS-MB	EMC-PARTNER AG
	Injection :	Coupling Clamp : CN-MIG-BT, CN-MIG-BT1 or CN-MIG-BT3	EMC-PARTNER AG
	Measurement :	HV-probe : 4kV, 100MHz Current probe : <b>I-Probe MB-P1</b> or similar	e.g. Fluke PM9100/101 EMC-PARTNER AG

#### 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 current limits are not exceeded.



CN-MIG-BT coupler can be used with **2T input** connected to the MIG-OS-MB. Use the white plastic strip to set a **2mm air gap** in the coupler core



CN-MIG-BT1 coupler can be used connected to the MIG-OS-MB. Open the coupler and set an **air gap of 2cm** in the coupler core



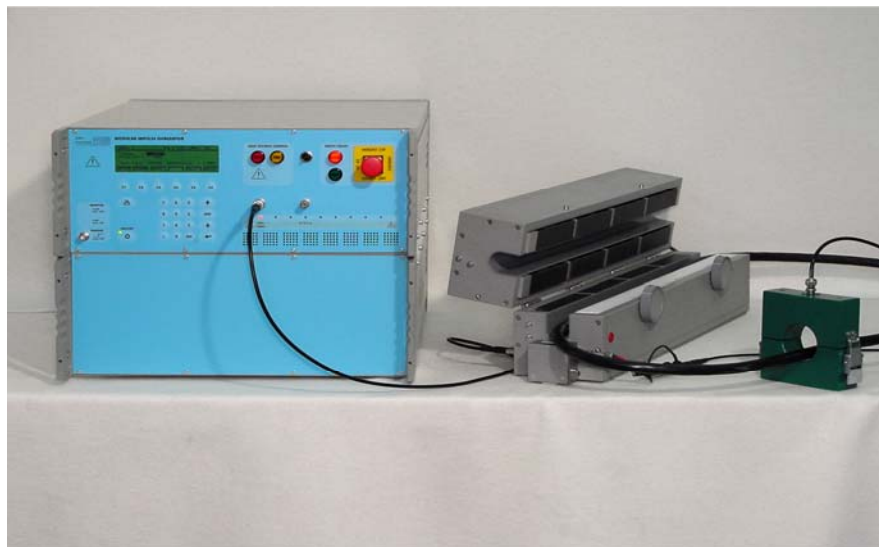
CN-MIG-BT3 coupler can be used connected to the MIG-OS-MB. Open the coupler and set an **air gap of 3cm** in the coupler core

#### Waveform 3: CB 10MHz Single stroke

#### Cable induction

Level	Test Voltage	Limit Current	Generator set-up	MIG-OS-MB
			Nominal Voltage	
1	100V	20A	300V	Waveshape : 3: CB 10MHz SS
2	250V	50A	750V	Repetition : 6.0s
3	600V	120A	1800V	Test-Time : 60s
[ 4 ]				Trigger Mode : auto
[ 5 ]				

- 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.





### 4.3.2 SS WF3 10MHz Level 4 - 5

<b>Equipment:</b>	Generator :	MIG-OS-MB-EXT+NW-W3-10M-FS	EMC-PARTNER AG
	Injection :	Coupling Clamp : CN-MIG-BT1 or CN-MIG-BT3	EMC-PARTNER AG
	Measurement :	HV-probe : 4kV, 100MHz	e.g. Fluke PM9100/101
		Current probe : <b>I-Probe MB-P1</b> or similar	EMC-PARTNER AG

#### Test Set-up:

Connect the MIG-OS-MB-EXT 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 current limits are not exceeded.



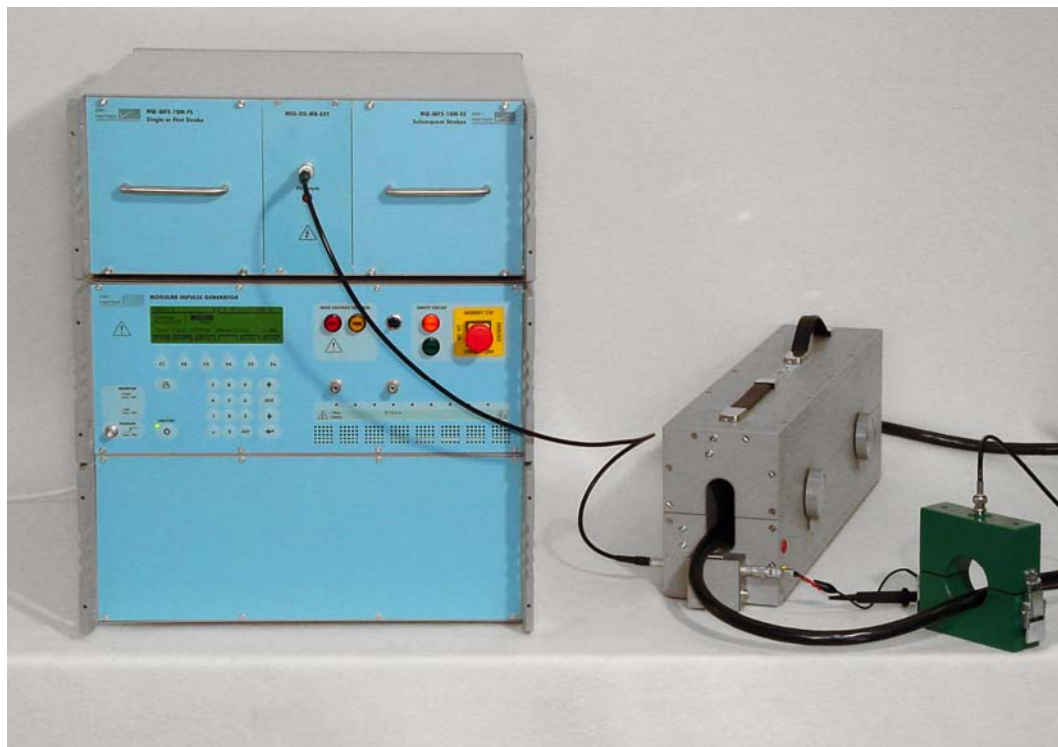
Select coupling via BT3 ON or OFF as appropriate

#### Waveform 3: CB 10MHz Single stroke

#### Cable induction

Level	Test Voltage	Limit Current	Generator set-up Nominal Voltage	MIG-OS-MB-EXT
1				Waveshape : 3: Extern 10M SS
2				Repetition : 6.0s
3				Test-Time : 60s
4	1500V	300A	1500V	Trigger Mode : auto
5	3200V	640A	3200V	

- With MIG-OS-MB-EXT and the NW-WF3-10M-FS the level 5 test voltage can be reached for inductances greater about 1  $\mu$ H. For a calculation of self inductance see chapter 6.



## 5 CABLE BUNDLE TESTS, MULTIPLE STROKE, TABLE 22-4

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%

### 5.1 CB-MS: WF2 0.1/6.4µs:

<b>Equipment:</b>	Generator :	MIG-OS-MB	EMC-PARTNER AG	
	Injection :	Coupling clamp : CN-MIG-BT, CN-MIG-BT1 or CN-MIG-BT3	EMC-PARTNER AG	
	Measurement :	HV-probe :	4kV, 100MHz	e.g. Fluke PM9100/101
		Current probe :	<b>I-Probe MB</b> or similar	EMC-PARTNER A

#### 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.

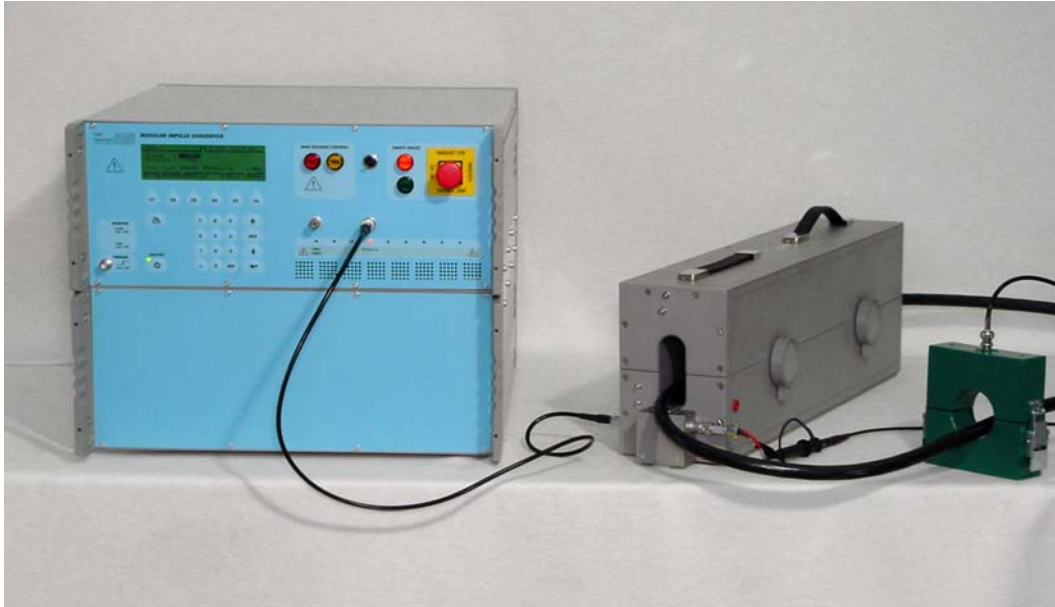


**Select coupling via BT3 ON or OFF as appropriate**

#### 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
2	125V	62.5V	125A	62.5A	125V	Attenuation :	1/2 (Subsequent)
3	300V	150V	300A	150A	300V	Pattern Nbr. :	12
4	750V	375V	750A	375A	750V	Repetition :	10.0s
[ 5 ]	1600V	800V	1600A	800A	1600V	Test-Time :	100s

- 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.



Waveform 2 is used only for unshielded cables.

### Test Setup with MIG-OS-MB-EXT

<b>Equipment:</b>	Generator :	MIG-OS-MB + MIG-OS-MB-EXT + NW-WF2-FS + NW-WF2-SS	EMC-PARTNER AG
	Injection :	Coupling clamp : CN-MIG-BT1 or CN- MIG-BT3	EMC-PARTNER AG
	Measurement :	HV-probe : 4kV, 100MHz Current probe : <b>I-Probe MB</b> or similar	e.g. Fluke PM9100/101 EMC-PARTNER A

#### Test Set-up:

Connect the MIG-OS-MB-EXT 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. Monitor the current in the cable bundle with a current probe to ensure the limit current is not exceeded.

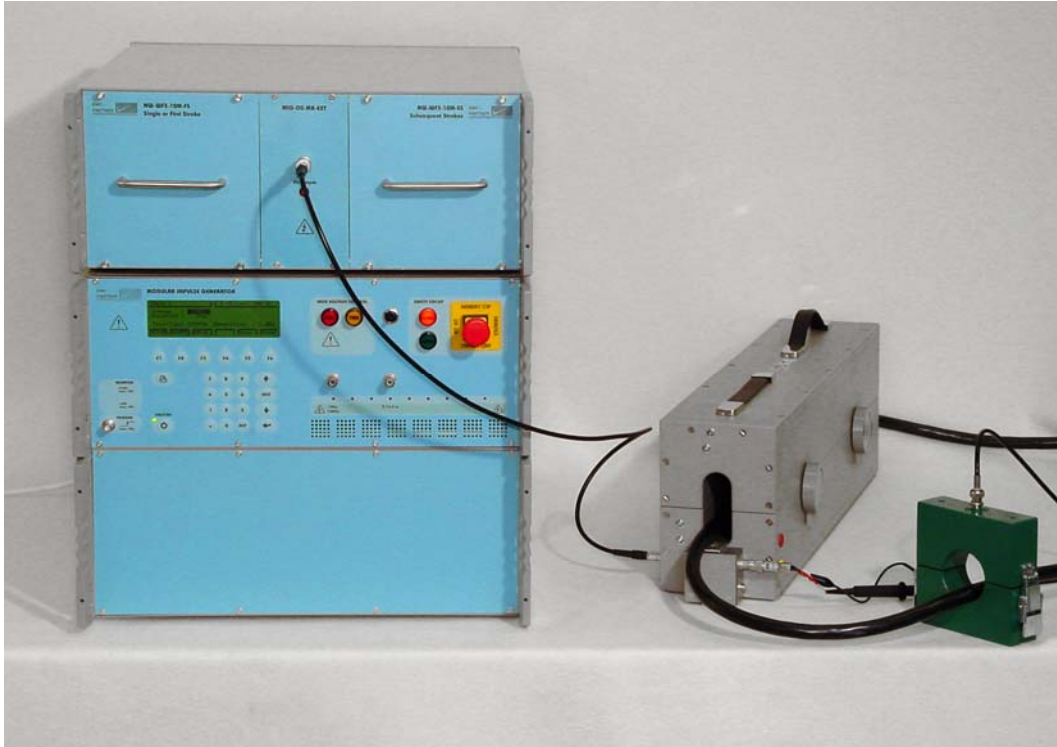


**Select coupling via BT3 ON or OFF as appropriate**

**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-EXT
	First	Subs.	First	Subs.	Nominal Voltage	Waveshape : Pattern Nbr. : Repetition : Test-Time :
1						2: CB 0.1/6.4us
2						12
3						10.0s
4	750V	375V	750V	375A	750V	100s
5	1600V	800V	1600A	800A	1600V	

- With MIG-OS-MB-EXT and the NW-WF2 the level 5 test voltage can be reached for inductance greater than about 3  $\mu$ H. For a calculation of self inductance see chapter 6.
-



To maintain the WF2 pulse duration within the DO160 tolerances, an air gap spacer must be placed in the CN-MIG-BT1 coupler as shown below.



Waveform 2 is used only for unshielded cables.

## 5.2 CB-MS: W3 1MHz

### 5.2.1 MS WF3 1MHz Level 1 - 3

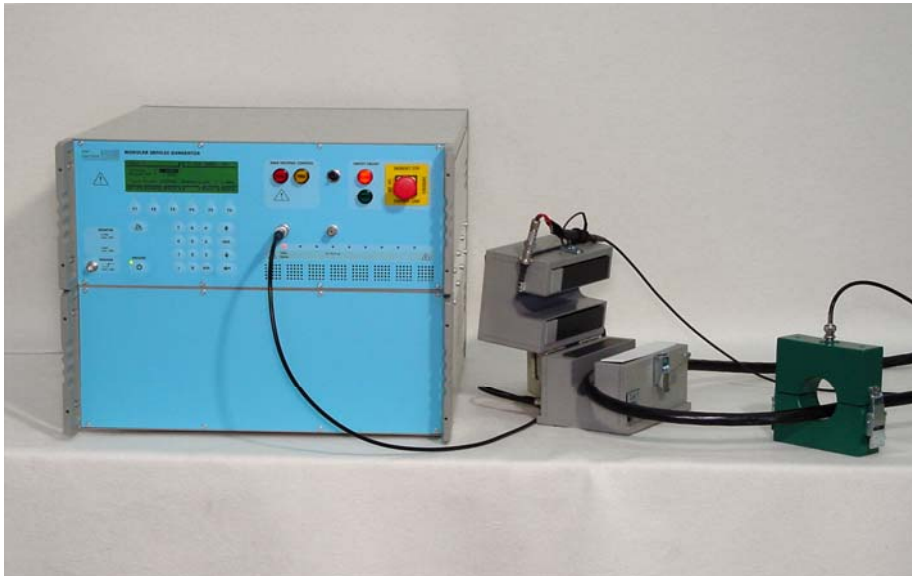
<b>Equipment:</b>	Generator :	MIG-OS-MB	EMC-PARTNER AG	
	Injection :	Coupling clamp : CN-MIG-BT	EMC-PARTNER AG	
	Measurement :	HV-probe :	4kV, 100MHz	e.g. Fluke PM9100/101
		Current probe :	<b>I-Probe MB</b> or similar	EMC-PARTNER AG

#### Test Set-up:

Connect the generator using the 1meter SHV cable to the coupling clamp CN-MIG-BT **COIL 1 INPUT**. Fit the white plastic strip in the coupler to provide the 2mm air gap. Place 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-BT.

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	400V	Waveshape : 3: CB 1MHz MS Attenuation : 1/2 (Subsequent)
2	250V	125V	50A	25A	1000V	Pattern Nbr. : 12
3	600V	300V	120A	60A	2400V	Repetition : 10.0s
[ 4 ]						Test-Time : 100s
[ 5 ]						

- Level 1, 2 and 3 should 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.



**For negative polarity, turn the coupler on the test cable.**

## 5.2.2 MS WF3 1MHz Level 4 - 5

<b>Equipment:</b>	Generator :	MIG-OS-MB + MIG-OS-MB-EXT + NW-W3-1M-FS + NW-W3-1M-SS	EMC-PARTNER AG
	Injection :	Coupling Clamp : CN-MIG-BT1 or CN-MIG-BT3	EMC-PARTNER AG
	Measurement :	HV-probe : 4kV, 100MHz Current probe : <b>I-Probe MB-P1</b> or similar	e.g. Fluke PM9100/101 EMC-PARTNER AG

### Test Set-up:

Connect the MIG-OS-MB-EXT 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. Monitor the current in the cable bundle with a current probe to ensure the limit current is not exceeded.



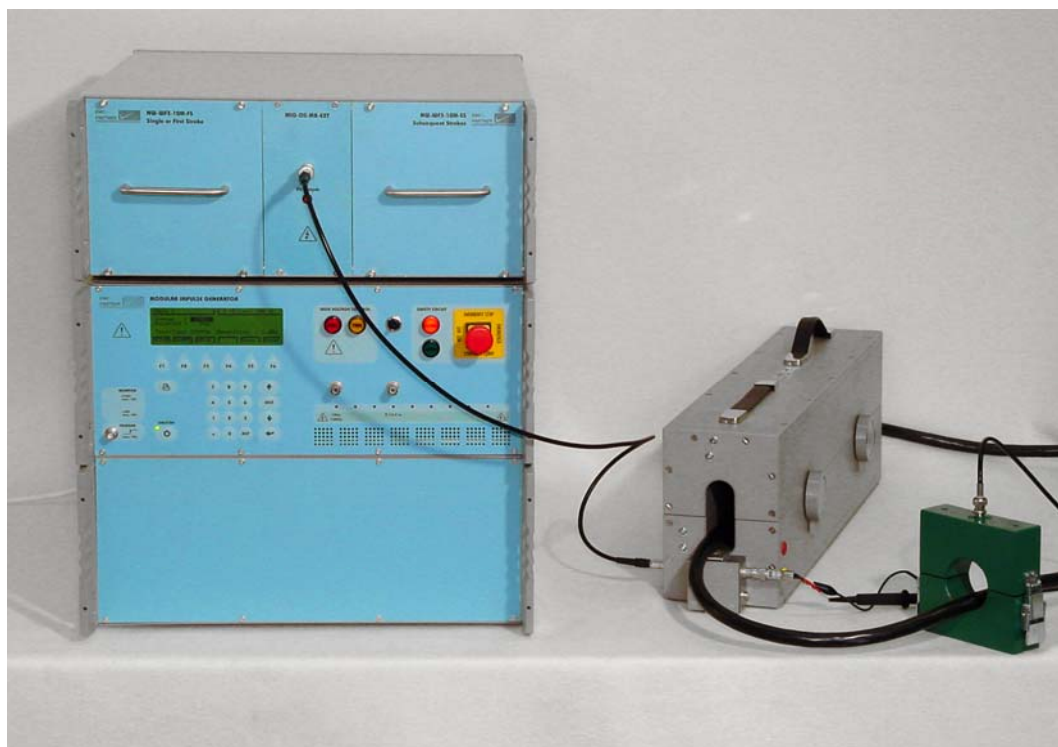
**Select coupling via BT3 ON or OFF as appropriate**

### 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-EXT
	First	Subs.	First	Subs.	Nominal Voltage	Waveshape : Pattern No. Repetition : Test-Time :
1						3: Extern 1M MS
2						12
3						10.0s
4	1500V	750V	300A	150A	1500V	100s
[ 5 ]	3200V	1600V	640A	320A	3200V	

- With MIG-OS-MB-EXT and the NW-WF3-1M the level 5 test voltage can be reached for inductances greater than about 1  $\mu$ H. For a calculation of self inductance see chapter 6.



### 5.3 CB-MS: W3 10 MHz:

#### 5.3.1 MS WF3 10MHz Level 1 - 3

<b>Equipment:</b>	Generator :	MIG-OS-MB	EMC-PARTNER AG	
	Injection :	Coupling clamp : CN-MIG-BT	EMC-PARTNER AG	
	Measurement :	HV-probe :	4kV, 100MHz	e.g. Fluke PM9100/101
		Current probe :	<b>I-Probe MB</b> or similar	EMC-PARTNER AG

#### Test Set-up:

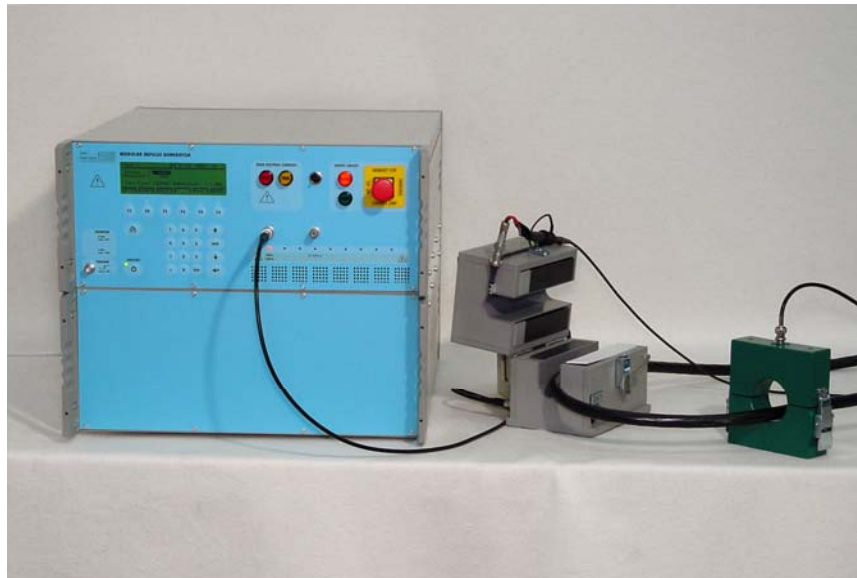
Connect the generator using the 1meter SHV cable to the coupling clamp CN-MIG-BTx. Insert the cable bundle into the coupling clamp. Set the voltage to the nominal value and run the generator. Increase the voltage with the up/down switch until the Test-Voltage is reached. Measure the test-voltage with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



CN-MIG-BT coupler can be used with **2T input** connected to the MIG-OS-MB. Use the white plastic strip to set a **2mm air gap** in the coupler core



CN-MIG-BT1 coupler can be used connected to the MIG-OS-MB. Open the coupler and set an **air gap of 2cm** in the coupler core



**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	200V	Waveshape : 3: CB 10MHz MS
2	250V	125V	50A	25A	500V	Attenuation : 1/2 (Subsequent)
3	600V	300V	120A	60A	1200V	Pattern Nbr. : 12
						Repetition : 10.0s
						Test-Time : 100s

- Level 1, 2 and 3 should 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.



**For negative polarity, turn the coupler on the test cable.**

### 5.3.2 MS WF3 10MHz Level 4 - 5

<b>Equipment:</b>	Generator :	MIG-OS-MB + MIG-OS-MB-EXT + NW-W3-10M-FS+ NW-W3-10M-SS	EMC-PARTNER AG
	Injection :	Coupling Clamp : CN-MIG-BT1 or CN-MIG-BT3	EMC-PARTNER AG
	Measurement :	HV-probe : 4kV, 100MHz Current probe : <b>I-Probe MB-P1</b> or similar	e.g. Fluke PM9100/101 EMC-PARTNER AG

#### Test Set-up:

Connect the MIG-OS-Mb-EXT 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.

Monitor the current in the cable bundle with a current probe to ensure the limit current is not exceeded.



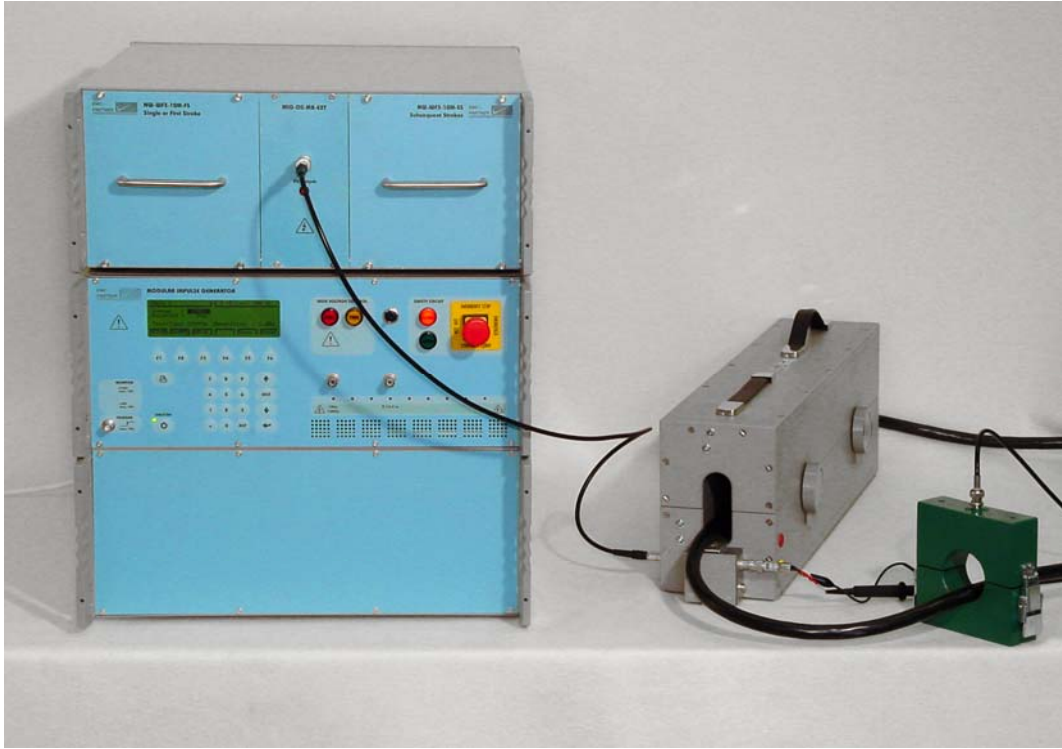
**Select coupling via BT3 ON or OFF as appropriate**

#### 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						Waveshape : 3: CB 10MHz MS
2						Pattern Nbr. : 12
3						Repetition : 10.0s
4	1500V	750V	300A	150A	1500V	Test-Time : 100s
[ 5 ]	3200V	1600V	640A	320A	3200V	

- 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.





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

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 :

### 6.1 CB-MB: W3H : 1MHz and 10MHz

#### 22-5 Cable Bundles, Multiple Burst

<b>Equipment:</b>	Generator :	MIG-OS-MB	EMC-PARTNER AG
	Injection :	Coupling clamp : CN-MIG-BT, CN-MIG-BT1 or CN-MIG-BT3	EMC-PARTNER AG
	Measurement :	HV-probe : 4kV, 100MHz	e.g. Fluke PM9100/101
		Current probe : <b>I-Probe MB</b> or similar	EMC-PARTNER AG

#### 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.



For 1MHz testing ensure the coupler is closed with NO air gap

#### Waveform 3H: CB 1MHz Multiple Burst

Level	Test Voltage	Limit Current	Generator set-up	
			Nominal Voltage	Waveshape : 3: CB 1MHz 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 should 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)

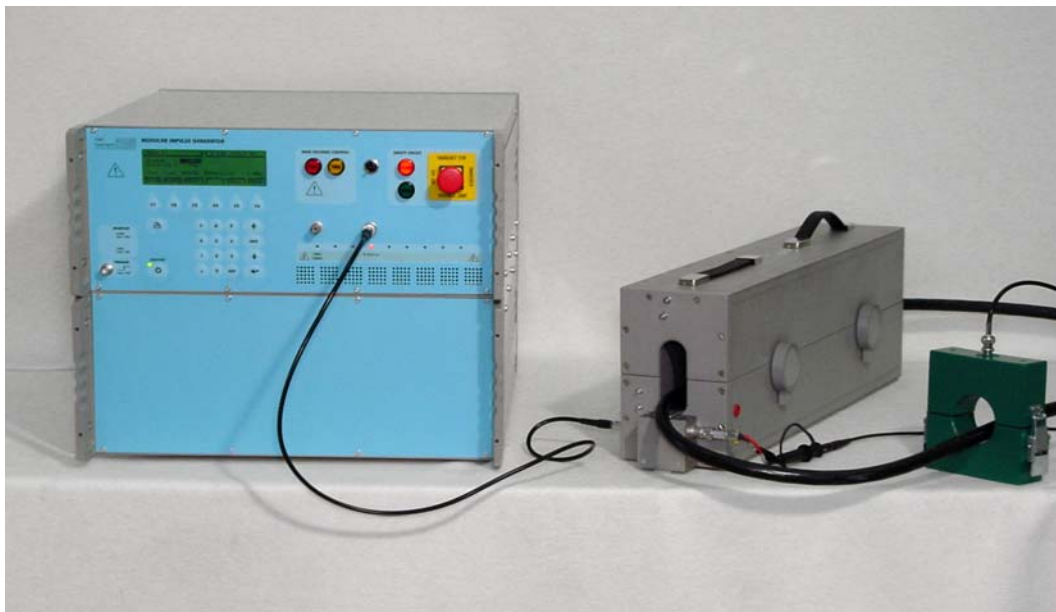


For 10MHz testing open the coupler and set and **air gap of 2cm** in the coupler core

### Waveform 3H: CB 10MHz Multiple Burst

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



## 6.2 CB-MB: W6H : 0.224/4us

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

### 22-5 Cable Bundles, Multiple Burst

<b>Equipment:</b>	Generator :	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 :	<b>I-Probe MB</b> or similar	EMC-PARTNER AG

#### Test Set-up:

Connect the MIG-OS-MB-EXT using the 1meter SHV cable to the coupling clamp CN-MIG-BTx. Insert the cable bundle into the coupling clamp. Set the current to the nominal value and run the generator. Increase the current until the test-current is reached.

Measure the current in the cable bundle with a current probe.

Monitor the limit-voltage with a HV-probe at the monitor loop of the coupling clamp CN-MIG-BTx to ensure the limit voltage is not exceeded.

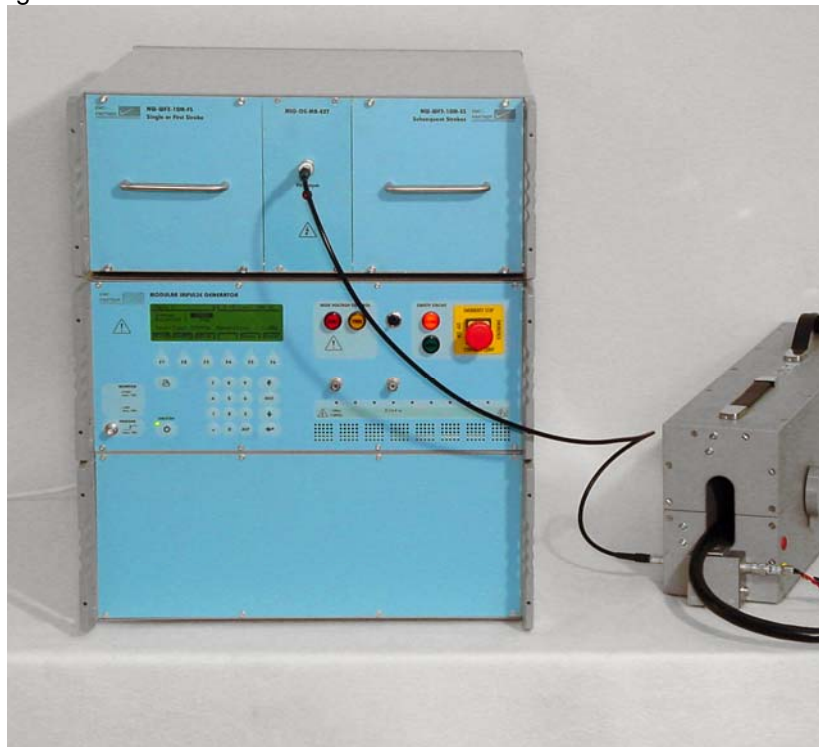


Fig: MIG-OS-MB with MIG-OS-MB-EXT and NW-WF-6H

#### Waveform 6H : CB 0.224/4us Multiple Burst

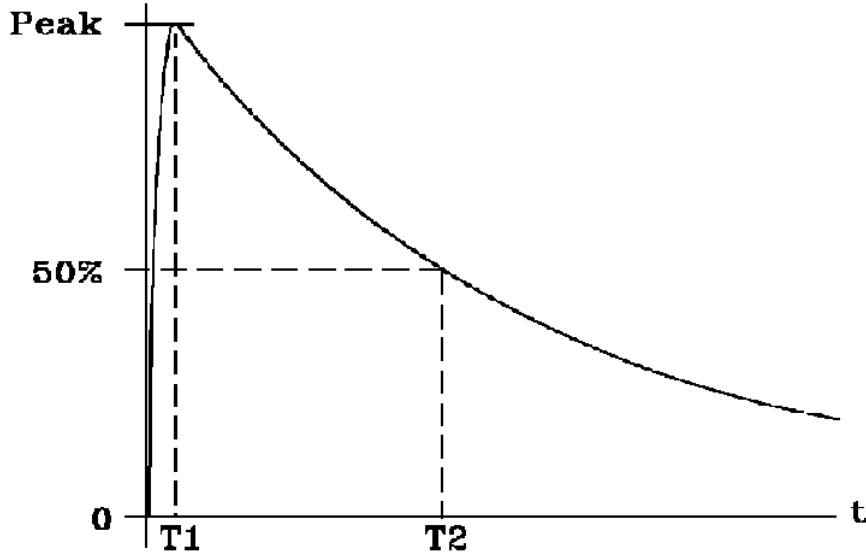
Level	Test Current	Limit Voltage	Generator set-up	
			Nominal Current	Waveshape : 0.224/4us M-Burst
1	5A	70V	5A	Pattern Nbr. : 11
2	12.5A	180V	13A	Coupling via CDN: on
3	30A	430V	30A	Repetition : 3.0s
4	75A	1080V	75A	Test-Time : 300s
5	160A	2290V	160A	Trigger Mode : auto

- Level 1, 2, 3, 4 and 5 should 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

# 7 PARTICULAR MEASUREMENT ISSUES

## 7.1 Impulse measurements in DO160

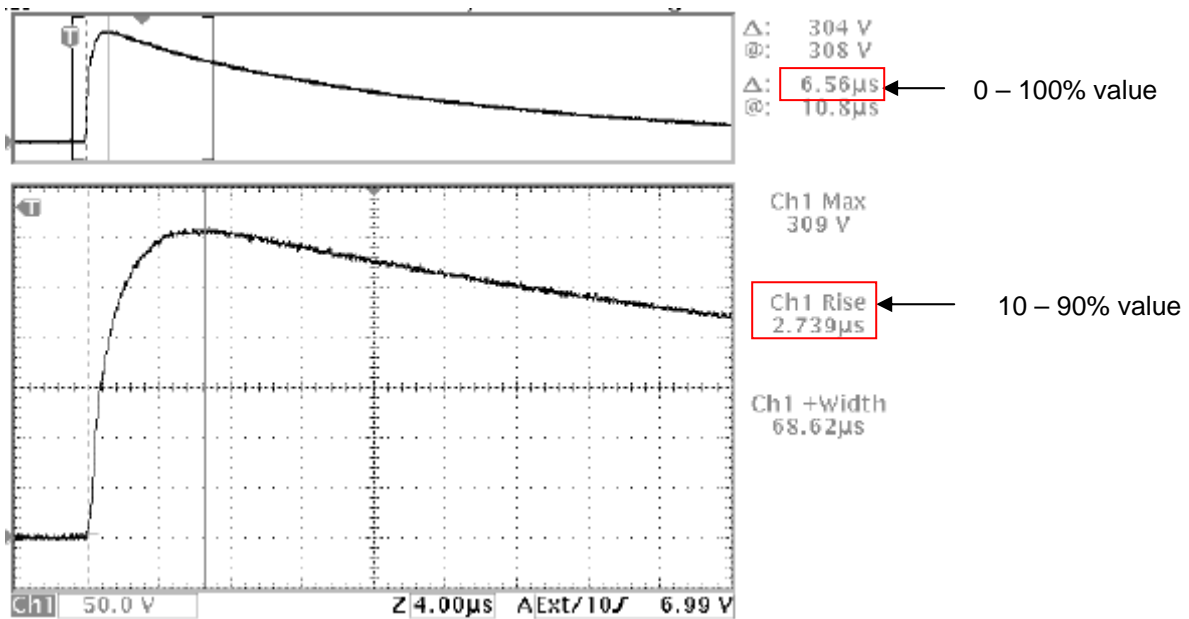
Impulses in DO160 are specified as follows:



T1 Risetime: 0% to 100% (peak)

T2 Duration: 0% to 50% ( exception WF2 = 0% to 0%)

Digital oscilloscopes with automatic measurement functions, can only evaluate impulses from 10 to 90% Evaluation according to DO160 can only be performed manually. EMCP verification reports include measurements made with the automatic oscilloscope evaluation, for speed, and a manual measurement using cursors. The upper (smaller) curve is the result of a manual evaluation. This can be compared to the automatic measurement from the oscilloscope in the lower (larger) curve.



## 7.2 Dealing with calibration when second peak is higher than first peak

Calibration of the W3 is made throughout the EMC PARTNER calibration report based on the first peak being 100%. When the second peak is higher than the first peak, which could be the case especially with 10MHz, then the calibration and test set up differs from the calibration report as follow

### W3: L1 to L3 Test set-up:

Use MIG-OS-MB with the CN-MIG-BT coil 2 input

### W3: L4 and L5 Test set-up:

Use MIG-OS-MB-EXT with CN-MIG-B1 or BT3.

Select the optimum air gap on the coupler for best Q factor.

## 7.3 Verification of high current >600A with W3 1MHz

Equipment:	Generator :	MIG-OS-MB + MIG-OS-MB-EXT+ NW-W3-1M-FS	EMC-PARTNER AG
	Injection :	Coupling Clamp : CN-MIG-BT	EMC-PARTNER AG
		Current probe : <b>I-Probe MB-P1</b> or similar	EMC-PARTNER AG

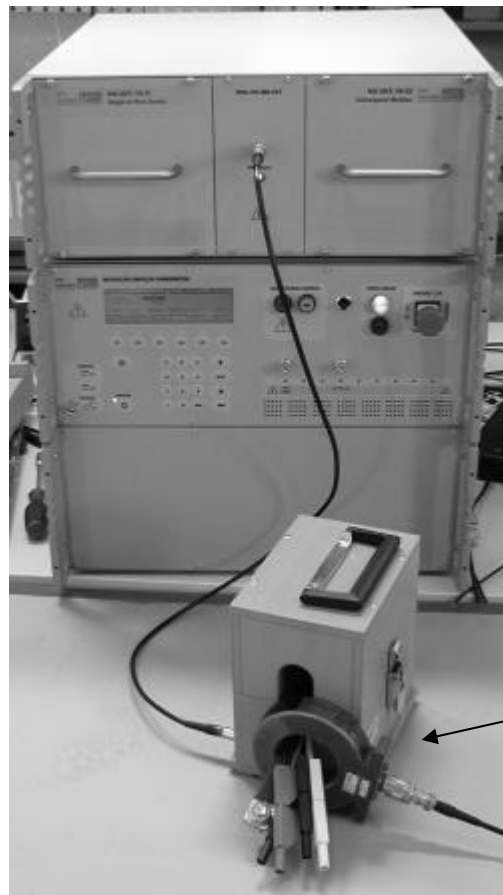


### Select coupling via BT3 ON in MIG-OS-MB menu

Connect the MIG-OS-MB-EXT using the 1meter SHV cable to the coupling clamp CN-MIG-BT **COIL 2 INPUT**. Insert a low inductive short circuit into the coupling clamp. A low impedance loop can be made with at least 5 banana cables (length 0.5 m each) in parallel. Set the voltage to the maximum value and run the generator.

Measure the current in the short circuit with a current probe.

With this set up the current will be > 600A



CN-MIG-BT on ground plane

## 7.4 AC Limits for Cable Induced Testing using CN-MIG-BTx Couplers

Using CN-MIG-BTx couplers on cable bundles containing AC power lines, can result in power being transferred back into the MIG-OS-MB generator impulse circuits. The coupling is frequency dependant increasing with frequency. At 400Hz, the coupling is significant and measures must be taken to limit AC current flowing into the generator.

Use of the AC/DC decoupler (part of CN-MIG-TT) reduces the amount of current coupled back into the generator.



AC/DC decoupler **MUST** be fitted to the CN-MIG-BTx coupler and **NOT** directly on the generator output.

The three coupler types, CN-MIG-BT, CN-MIG-BT1 and CN-MIG-BT3 have different coupling coefficients due to their physical properties (length).

The table below is a guide to the maximum frequency / current combination possible **WITHOUT** the AC/DC decoupler.

<b>Coupler</b>	<b>Frequency</b>	<b>50 / 60Hz</b>	<b>400 / 800Hz</b>
CN-MIG-BT		100Aac	20A
CN-MIG-BT1		100Aac	12A
CN-MIG-BT3		100Aac	16A

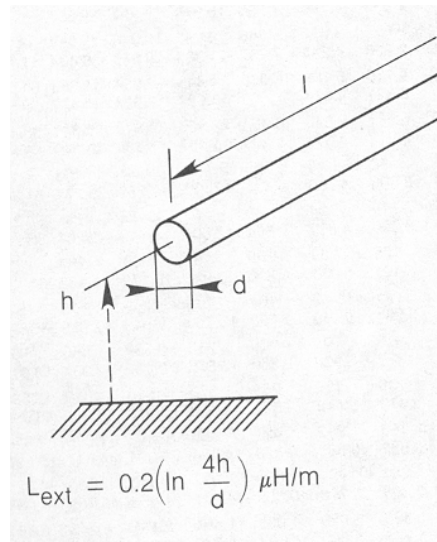




## 8 APPROXIMATION OF SELF INDUCTANCE

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.

### 8.1 Wire above ground plane



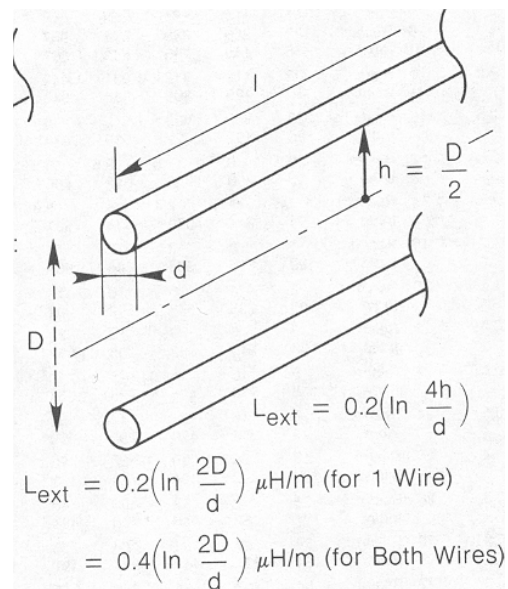
**Example:**

Height  $h = 0.1\text{m}$

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

**L<sub>ext.</sub> = 1.02 μH**

### 8.2 Two round wires



**Example:**

**One wire**

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

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

**L<sub>ext.</sub> = 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<sub>ext.</sub> = 1.75 μH**

### 8.3 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 $\mu\text{H}$ 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.

### 8.4 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  $\mu\text{H}$  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

W2 level SS = 3200 / 0.1  $10^{-6}$  = 32  $10^9$  A/seconds

Example: W2 0.1/6.4  $\mu\text{s}$  L = 0.5  $\mu\text{H}$

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

Example: W1 6.4/70 $\mu\text{s}$  L = 0.5  $\mu\text{H}$

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

## 8.5 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

The following examples indicate the **TEST** voltage that must be present to drive 640A in a cable bundle.

### Example W3 1MHz Level 5 single wire

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



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

### Example W3 1MHz Level 5 cable bundle

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

### Example W3 10 MHz Level 5 cable bundle

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



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