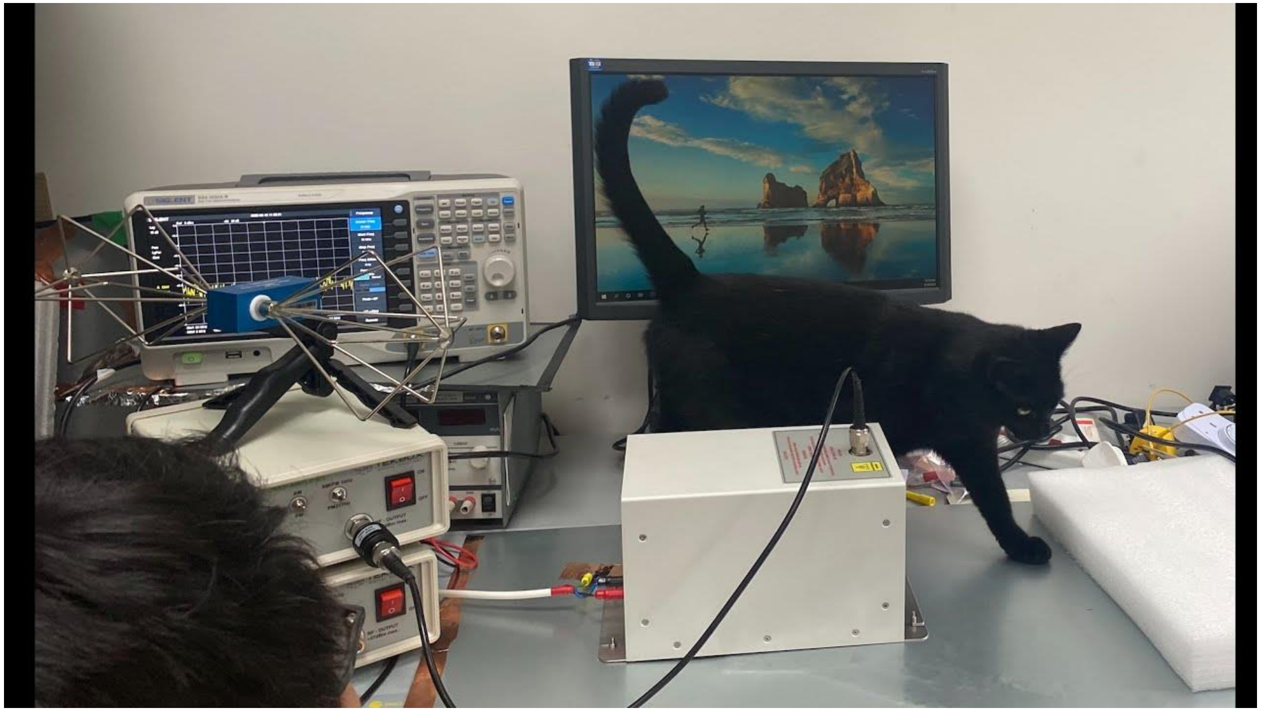
V1.0

传导抗扰度试验



深圳市国测电子有限公司

传导抗扰度测试
主要标准

- IEC/EN 61000-4-6基本，工业和家用产品
  - ISO 11452-4汽车
  - MIL-STD-461G防御
  - RTCA DO-160C航空电子设备

频率范围：

IEC / EN 61000-4-6	150 kHz – 80 MHz (230 MHz)
ISO11452-4 汽车电子	1 MHz – 400 MHz
MIL-STD-461G 美军标	10 kHz – 400 MHz
RTCA DO-160C 航空电子	10 kHz – 400 MHz

IEC/EN 61000-4-6规定了150欧姆系统中开路电压的应力水平。所有其他标准都规定了注入电流的应力水平。

传导抗扰度测试
传感器

IEC / EN 61000-4-6	CDN, BCI夹具、EM夹具
ISO11452-4	BCI-夹具
MIL-STD-461G	BCI-夹具
RTCA DO-160C	BCI-夹具

IEC/EN 61000-4-6规定了上述任何换能器的抗扰度测试。然而，它明确优先考虑**CDN**，并规定了选择换能器的标准。**CDN**在从**150**千赫到**80**兆赫或从**150**千赫兹到**230**兆赫的频率范围内使用。对**CDN**的偏好来自于它们建立**150**欧姆的明确定义的**RF**阻抗的特性。

BCI夹具可用于将射频注入任何类型的电缆、电源线、数据线等。由于其非侵入性设计，它们非常容易应用。主要缺点是EUT和电源/AE之间缺乏去耦。BCI探头的带宽通常为150 kHz至100 MHz或250 MHz，用于EN 61000-4-6的抗扰度测试，或1 MHz至400 MHz，用于汽车抗扰度试验。

EM夹具用于无法使用CDN的地方。它们提供耦合和解耦。它们具有相对较低的插入损耗，因此只需要中等功率的RF放大器。它们可以在高达1GHz的频率范围内使用。

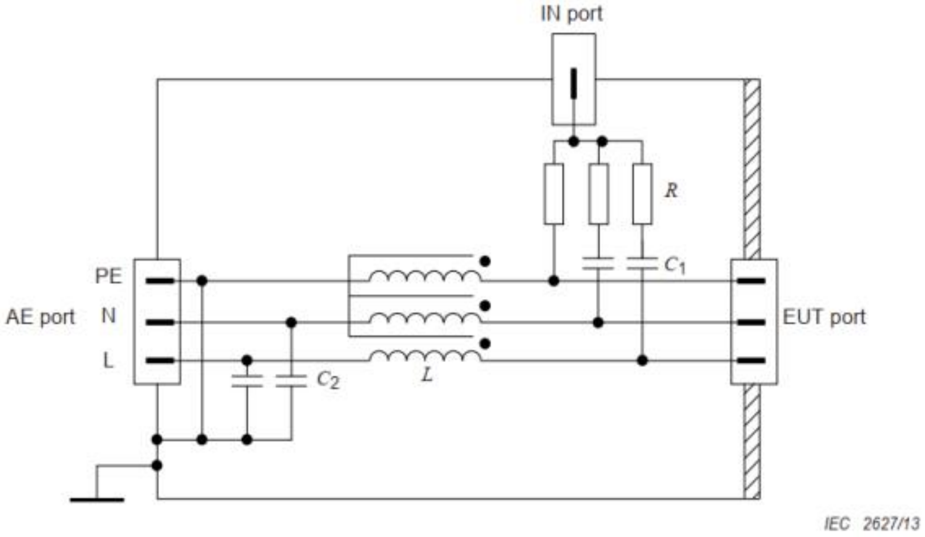
TEKBOX
TEKBOX
BULK CURRENT INJECTION PROBE

传导抗扰度测试

CDN

Line type	Examples	CDN - type
Power supply (AC and DC) and earth connection	AC mains DC in industrial installations Earth connection	CDN - Mx
Screened cables	Coaxial cables cables used for LAN and USB connections cables for audio systems	CDN - Sx
Unscreened balanced lines	ISDN lines telephone lines	CDN - Tx
Unscreened unbalanced lines	Any line not belonging to other groups	CDN – Afx or CDN - Mx

CDN的缺点：
它需要许多不同的型号



IEC 2627/13

CDN-M3, C_1 (typical) = 10 nF, C_2 (typical) = 47 nF, R = 300 Ω, $L \geq 280$ µH at 150 kHz

CDN-M2, C_1 (typical) = 10 nF, C_2 (typical) = 47 nF, R = 200 Ω, $L \geq 280$ µH at 150 kHz

CDN-M1, C_1 (typical) = 22 nF, C_2 (typical) = 47 nF, R = 100 Ω, $L \geq 280$ µH at 150 kHz

Figure D.2 – Example of simplified diagram for the circuit of CDN-M1/-M2/-M3 used with unscreened supply (mains) lines (see 6.2.2.2)

传导抗扰度测试
IEC 61000-4-6阻抗

- IEC/EN 61000-4-6测试模拟由射频发射器产生的电磁场引起的电磁干扰。

· 测试设备对辐射干扰的敏感性。

· 连接到设备的电缆表现为无源接收天线。关于电磁敏感性，假设连接的电缆处于谐振模式（λ/4、 λ/2开放或折叠偶极子等），共模阻抗为150Ω.

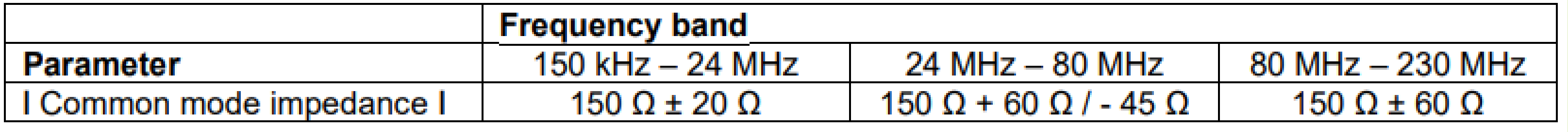
· 因此，测试装置通过耦合/去耦150欧姆的设备来替代谐振电缆（=具有150欧姆共模阻抗的天线）Ω共模阻抗。

· CDN内部电阻器：100Ω

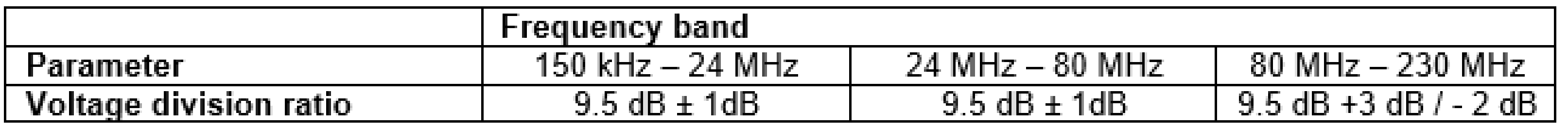
- 与50Ω 信号源阻抗：150欧姆

· 众所周知，宽带射频功率放大器匹配不佳

· 增加了一个6 dB衰减器，以改善CDN射频端口的匹配

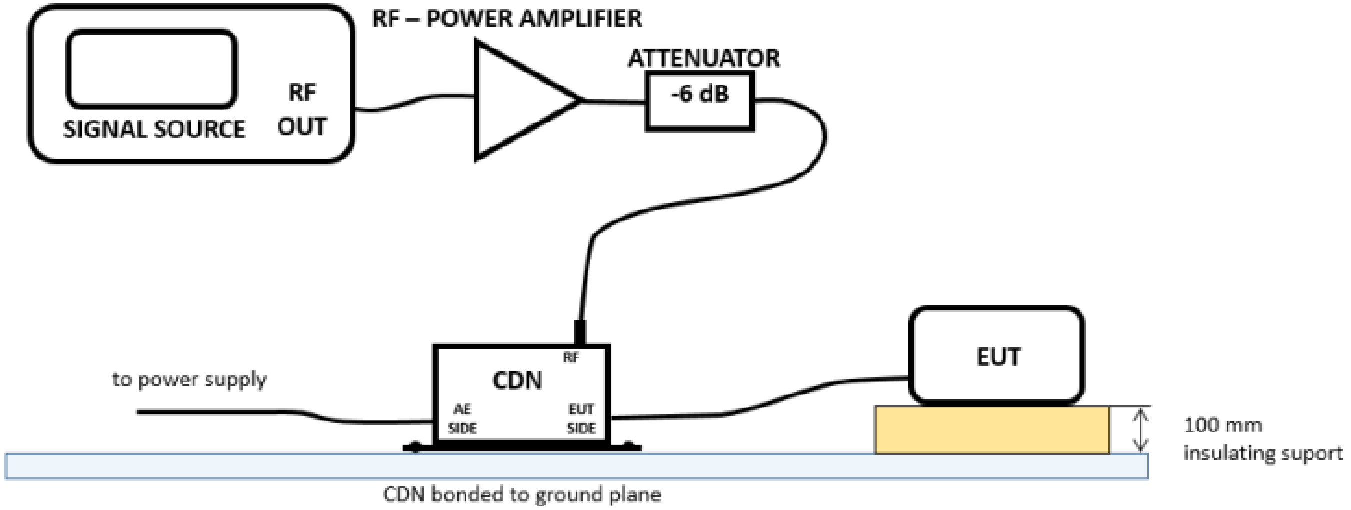


	Frequency band		
Parameter	150 kHz – 24 MHz	24 MHz – 80 MHz	80 MHz – 230 MHz
I Common mode impedance I	150 Ω ± 20 Ω	150 Ω + 60 Ω / - 45 Ω	150 Ω ± 60 Ω



	Frequency band		
Parameter	150 kHz – 24 MHz	24 MHz – 80 MHz	80 MHz – 230 MHz
Voltage division ratio	9.5 dB ± 1dB	9.5 dB ± 1dB	9.5 dB +3 dB / - 2 dB

传导抗扰度试验
IEC 61000-4-6试验等级


RF – POWER AMPLIFIER
SIGNAL SOURCE
RF OUT
ATTENUATOR
-6 dB
to power supply
CDN
RF
AE SIDE
EUT SIDE
EUT
100 mm insulating suport
CDN bonded to ground plane

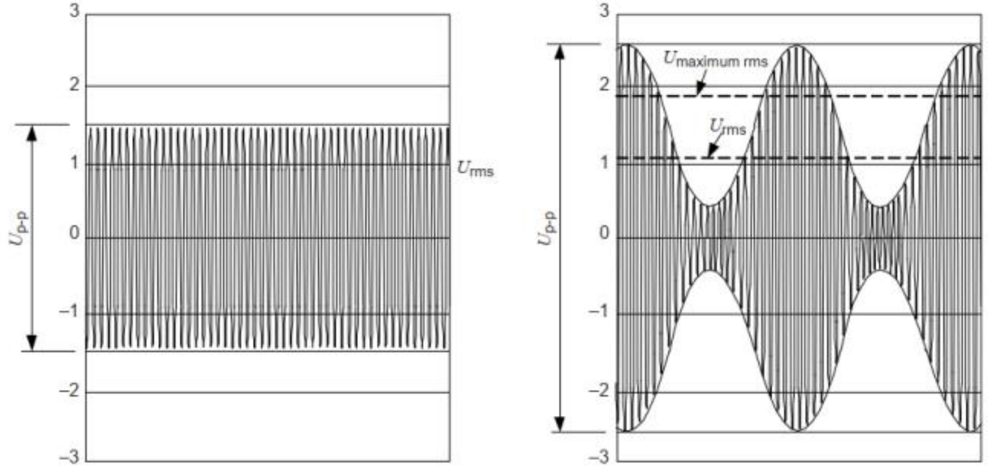
测试电平是在耦合设备的**EUT**端口设置的开路电压

Level	**Voltage level (e.m.f.)**	
	U_0 [V]	**U_0 [dBµV]**
1	1	120
2	3	129.5
3	10	140
X*	Special	

* "X" can be any level, above, below or in between the others. The level has to be specified in the dedicated equipment specification

传导抗扰度试验
IEC 61000-4-6试验等级

为了测试设备，该信号用1 kHz正弦波进行80%幅度调制，以模拟实际威胁。有效调幅如下所示：



a - Unmodulated RF signal
U_{p-p} = 2,82 V
U_{rms} = 1,00 V

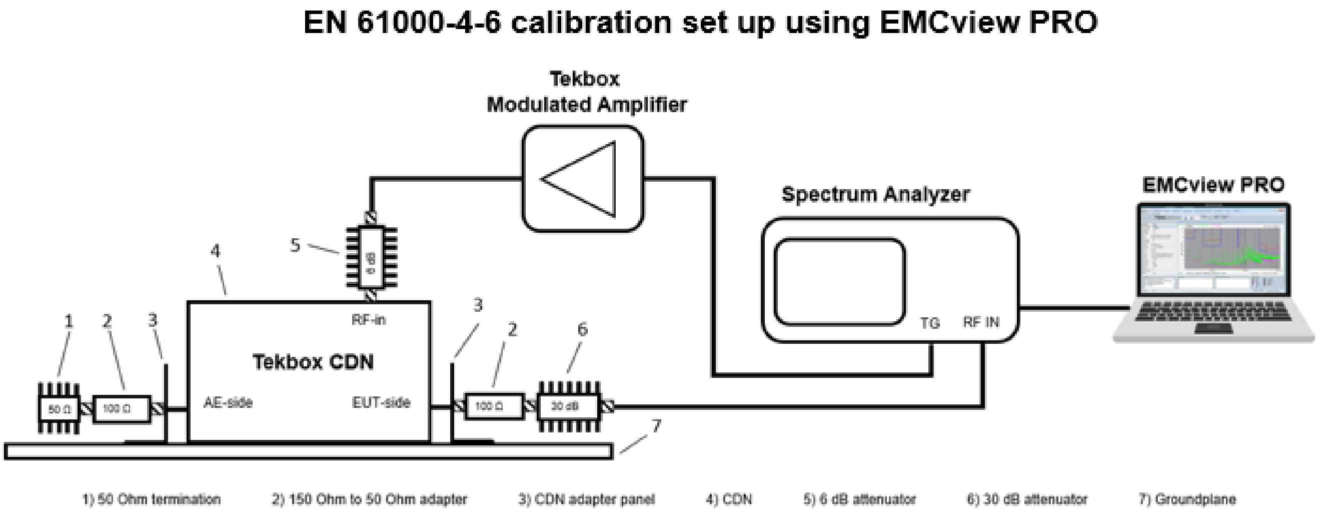
b - Modulated RF – signal 80 % AM
U_{p-p} = 5,09 V
U_{rms} = 1,12 V
$U_{maximum\ rms}$ = 1,80 V

Consequently, the level of the modulated signal must be 5.1 dB higher than the test levels specified by the standard. The insertion loss of a typical CDN is approximately 10 dB from RF input to the output of a 150 Ohm to 50 Ohm adapter at the EUT port. Adding a 6dB attenuator to improve matching of the RF power amplifiers would require following amplifier output power:

Level	unmodulated rms voltage	modulated rms voltage	unmodulated RF power	modulated RF power	Including 6 dB attenuator
1	1 V	1.8 V	6 mW / 7.6 dBm	19 mW / 12.7 dBm	74 mW / 18.7 dBm
2	3 V	5.4 V	50 mW / 17 dBm	204 mW / 23.1 dBm	0.8 W / 29.1 dBm
3	10 V	18 V	0.55 W / 27.4 dBm	1.8 W / 32.5 dBm	7.1 W / 38.5 dBm

传导抗扰度测试
IEC 61000-4-6校准

请注意，指定的应力水平电压是EUT端口的开路电压。校准期间测量的电压必须乘以3才能进行50欧姆到150欧姆的转换，再乘以2才能达到开路电压。因此，在校准期间测得的电压是所需应力水平的电压的1/6。在对数图中，测得的电压比开路电压低15.5 dB。


EN 61000-4-6 calibration set up using EMCview PRO
Tekbox
Modulated Amplifier
Spectrum Analyzer
EMCview PRO
TG
RF IN
5
6 dB
4
RF-in
Tekbox CDN
AE-side
EUT-side
1
2
3
50 Ω
100 Ω
3
2
6
100 Ω
30 dB
7
1) 50 Ohm termination
2) 150 Ohm to 50 Ohm adapter
3) CDN adapter panel
4) CDN
5) 6 dB attenuator
6) 30 dB attenuator
7) Groundplane

示例电平3：10V；150的输出电平Ω 至50Ω -> 10/6=1.66V=17.4 dBm分析仪输入处的相应电平：17.4 dBm-30 dB=-12.6 dBm

所需射频功率：

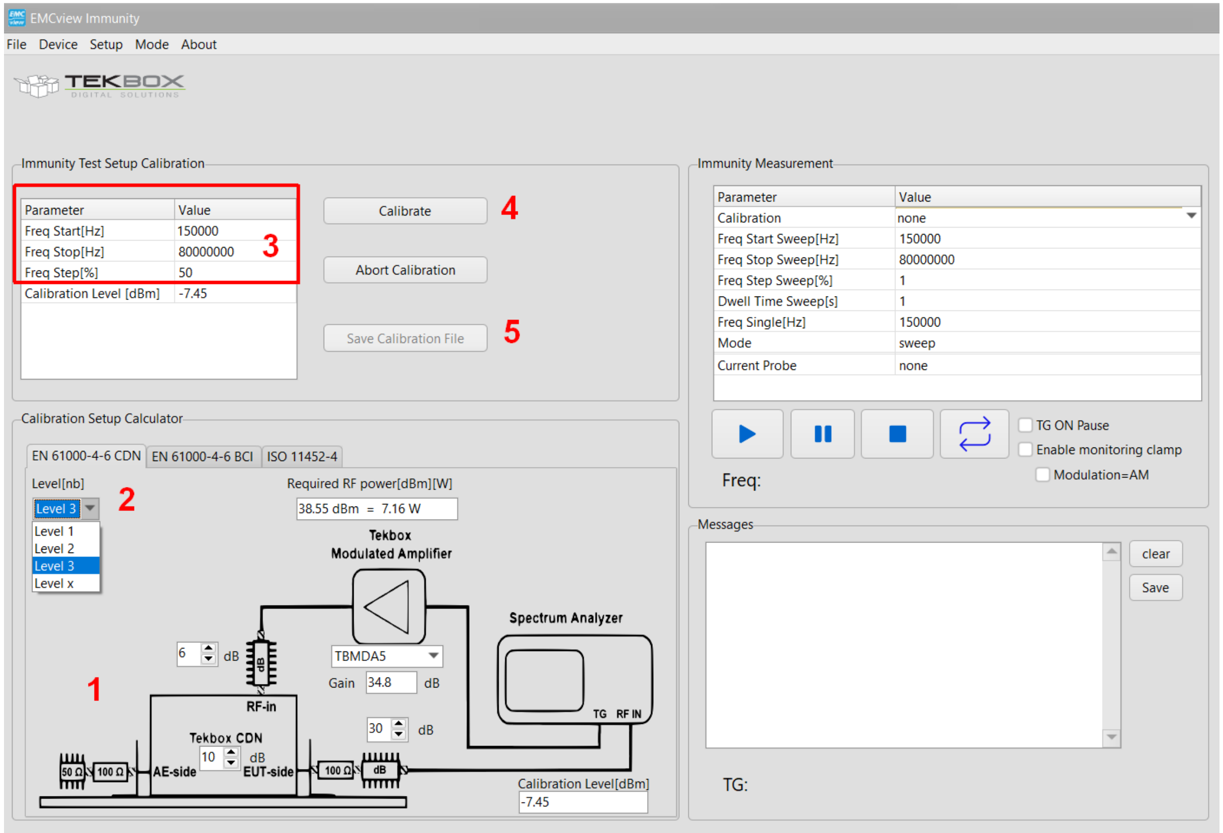
CDN插入损耗是在150欧姆适配器的输出端测量的，因此：

P=U0/6[dBm]+CDN插入损耗+6 dB（衰减器）+5.1 dB（80%AM RMS）=

=17.4 dBm+10 dB+6 dB+5.1 dB=38.5 dBm

传导抗扰度测试
IEC 61000-4-6校准

使用EMCview校准CDN设置：


EMCview Immunity
File
Device
Setup
Mode
About
TEKBOX DIGITAL SOLUTIONS
Immunity Test Setup Calibration
Calibrate
4
3
Abort Calibration
Save Calibration File
5
Immunity Measurement
Calibration Setup Calculator
EN 61000-4-6 CDN
EN 61000-4-6 BCI
ISO 11452-4
2
Level 1
Level 2
Level 3
Level x
Tekbox
Modulated Amplifier
Spectrum Analyzer
TG
RF IN
RF-in
1
Tekbox CDN
AE-side
EUT-side
50 Ω
100 Ω
100 Ω
dB
Freq:
Messages
clear
Save
TG:

Immunity Test Setup Calibration

Parameter	Value
Freq Start[Hz]	150000
Freq Stop[Hz]	80000000
Freq Step[%]	50
Calibration Level [dBm]	-7.45

Immunity Measurement

Parameter	Value
Calibration	none
Freq Start Sweep[Hz]	150000
Freq Stop Sweep[Hz]	80000000
Freq Step Sweep[%]	1
Dwell Time Sweep[s]	1
Freq Single[Hz]	150000
Mode	sweep
Current Probe	none

☐ TG ON Pause
☐ Enable monitoring clamp
☐ Modulation=AM

Level[nb]: Level 3
Required RF power[dBm][W]: 38.55 dBm = 7.16 W
6 dB
TBMDA5
Gain 34.8 dB
30 dB
10 dB
Calibration Level[dBm]: -7.45

步骤：

1.根据图纸设置
2.选择测试级别
3.设置频率扫描
4.开始校准
5.保存校准文件

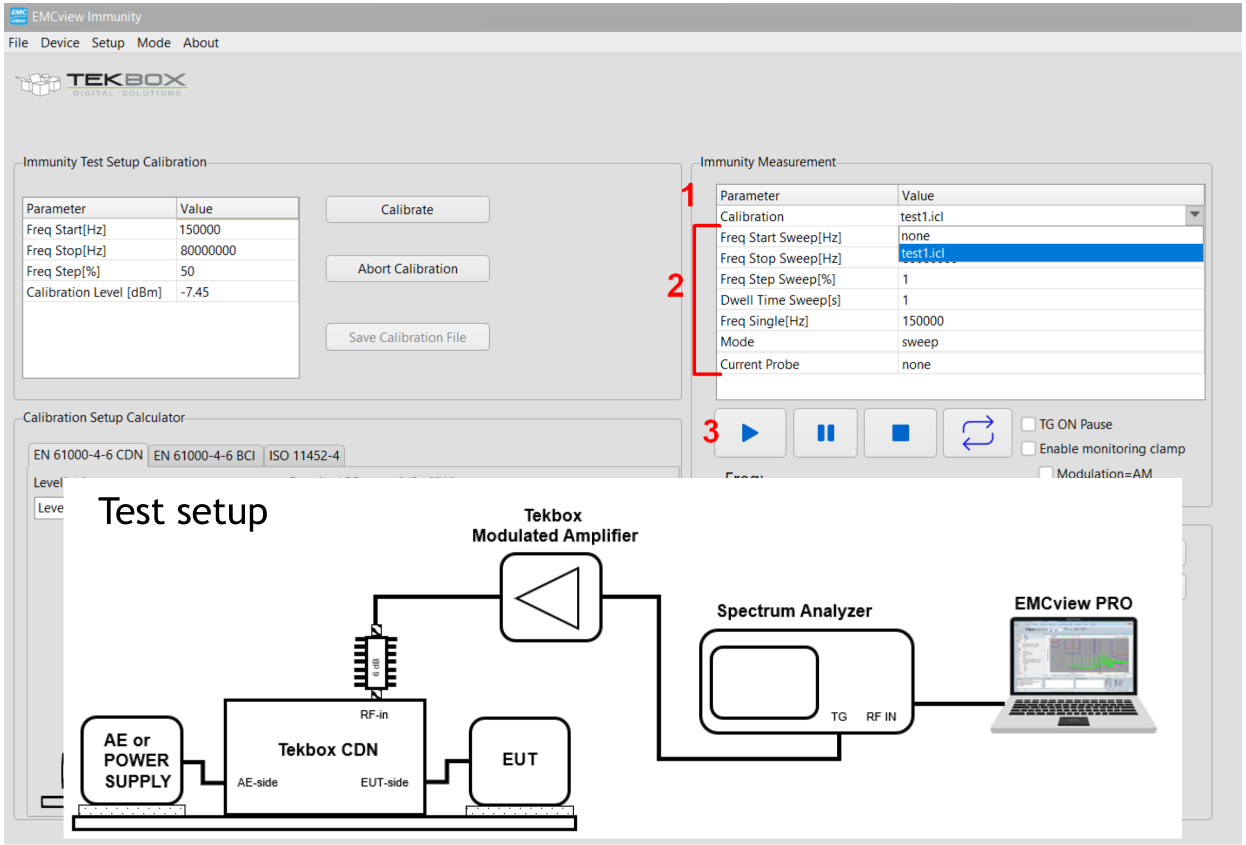
输出：

控制TG电平以在整个扫描过程中保持恒定干扰电压的校准文件

V1.0

传导抗扰度试验
IEC 61000-4-6抗扰度测试

使用EMCview进行CDN免疫测试：



EMCview Immunity

File
Device
Setup
Mode
About
TEKBOX DIGITAL SOLUTIONS

Immunity Test Setup Calibration

Parameter	Value
Freq Start[Hz]	150000
Freq Stop[Hz]	80000000
Freq Step[%]	50
Calibration Level [dBm]	-7.45

Calibrate
Abort Calibration
Save Calibration File

Immunity Measurement

Parameter	Value
Calibration	test1.icl
Freq Start Sweep[Hz]	none
Freq Stop Sweep[Hz]	test1.icl
Freq Step Sweep[%]	1
Dwell Time Sweep[s]	1
Freq Single[Hz]	150000
Mode	sweep
Current Probe	none

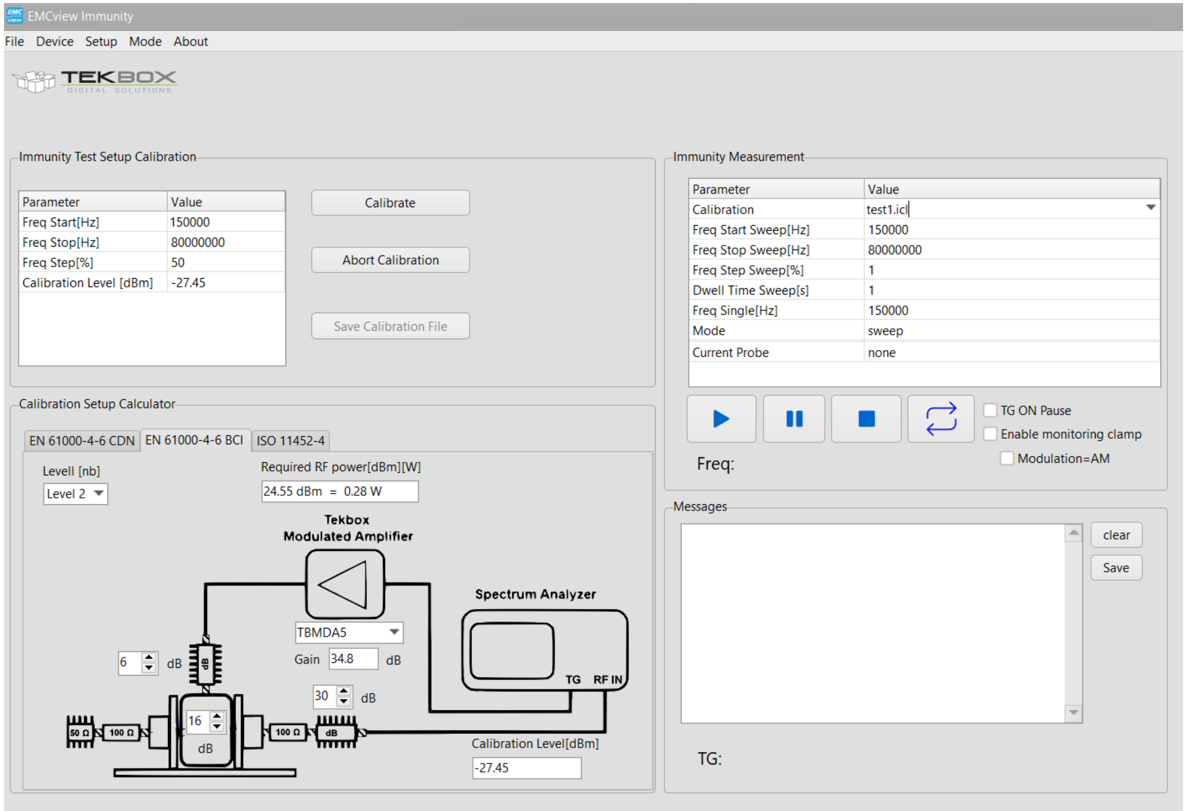
1
2
3
☐ TG ON Pause
☐ Enable monitoring clamp
☐ Modulation=AM
Calibration Setup Calculator
EN 61000-4-6 CDN
EN 61000-4-6 BCI
ISO 11452-4
Level
Leve
Test setup
Tekbox
Modulated Amplifier
Spectrum Analyzer
EMCview PRO
6 dB
RF-in
Tekbox CDN
AE-side
EUT-side
AE or
POWER
SUPPLY
EUT
TG
RF IN

步骤：

1.选择校准文件
2.选择扫描参数
3.启动抗扰度测试
4.监控EUT行为

传导抗扰度测试
IEC 61000-4-6校准

使用EMCview校准脑机接口探头（EM夹具）设置：


EMCview Immunity
File Device Setup Mode About
Calibrate
Abort Calibration
Save Calibration File
EN 61000-4-6 CDN
EN 61000-4-6 BCI
ISO 11452-4
Tekbox
Modulated Amplifier
Spectrum Analyzer
TG
RF IN
50 Ω
100 Ω
100 Ω
dB
clear
Save

Immunity Test Setup Calibration

Parameter	Value
Freq Start[Hz]	150000
Freq Stop[Hz]	80000000
Freq Step[%]	50
Calibration Level [dBm]	-27.45

Calibration Setup Calculator

Levell [nb]: Level 2

Required RF power[dBm][W]: 24.55 dBm = 0.28 W

TBMDA5

Gain 34.8 dB

6 dB

30 dB

16 dB

Calibration Level[dBm]: -27.45

Immunity Measurement

Parameter	Value
Calibration	test1.icl
Freq Start Sweep[Hz]	150000
Freq Stop Sweep[Hz]	80000000
Freq Step Sweep[%]	1
Dwell Time Sweep[s]	1
Freq Single[Hz]	150000
Mode	sweep
Current Probe	none

☐ TG ON Pause

☐ Enable monitoring clamp

☐ Modulation=AM

Freq:

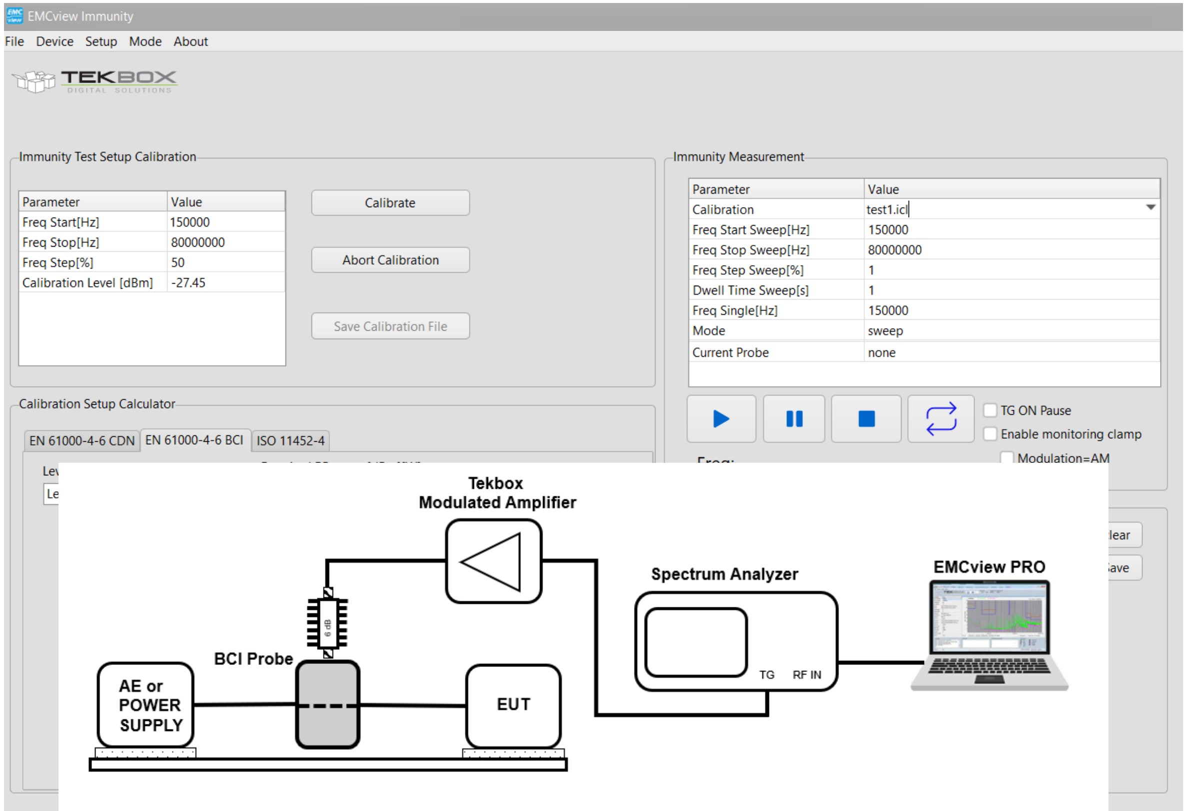
Messages

TG:

以与CDN设置相同的方式进行BCI设置校准

传导抗扰度试验
IEC 61000-4-6抗扰度测试

使用**EMCview**进行BCI探头（**EM**夹具）设置的免疫测试：


EMCview Immunity
File Device Setup Mode About
TEKBOX DIGITAL SOLUTIONS
Calibrate
Abort Calibration
Save Calibration File
EN 61000-4-6 CDN
EN 61000-4-6 BCI
ISO 11452-4
Tekbox Modulated Amplifier
6 dB
BCI Probe
AE or POWER SUPPLY
EUT
Spectrum Analyzer
TG
RF IN
EMCview PRO

Immunity Test Setup Calibration

Parameter	Value
Freq Start[Hz]	150000
Freq Stop[Hz]	80000000
Freq Step[%]	50
Calibration Level [dBm]	-27.45

Calibration Setup Calculator

Immunity Measurement

Parameter	Value
Calibration	test1.icl
Freq Start Sweep[Hz]	150000
Freq Stop Sweep[Hz]	80000000
Freq Step Sweep[%]	1
Dwell Time Sweep[s]	1
Freq Single[Hz]	150000
Mode	sweep
Current Probe	none

☐ TG ON Pause
☐ Enable monitoring clamp
☐ Modulation=AM

按照CDN设置中描述的相同方式执行抗扰度测试

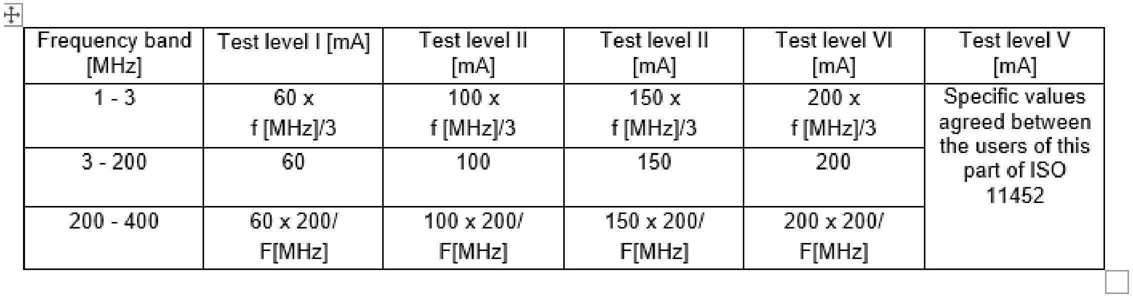
传导抗扰度测试

ISO 11452-4，MIL-STD-461G，RTCA-DO-160C

ISO 11452-4、MIL-STD-461G、RTCA-DO-160C规定了注入电流的应力水平。

示例ISO 11452-4

ISO 11452-4 specifies BCI severity test levels as displayed in Table 2 and Figure 2:



Frequency band [MHz]	Test level I [mA]	Test level II [mA]	Test level II [mA]	Test level VI [mA]	Test level V [mA]
1 - 3	60 x f [MHz]/3	100 x f [MHz]/3	150 x f [MHz]/3	200 x f [MHz]/3	Specific values agreed between the users of this part of ISO 11452
3 - 200	60	100	150	200	
200 - 400	60 x 200/ F[MHz]	100 x 200/ F[MHz]	150 x 200/ F[MHz]	200 x 200/ F[MHz]	

Table 2: BCI test severity levels

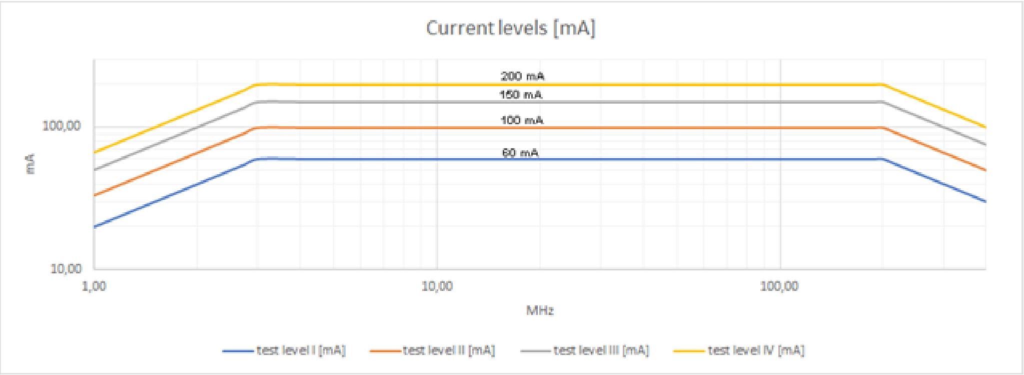


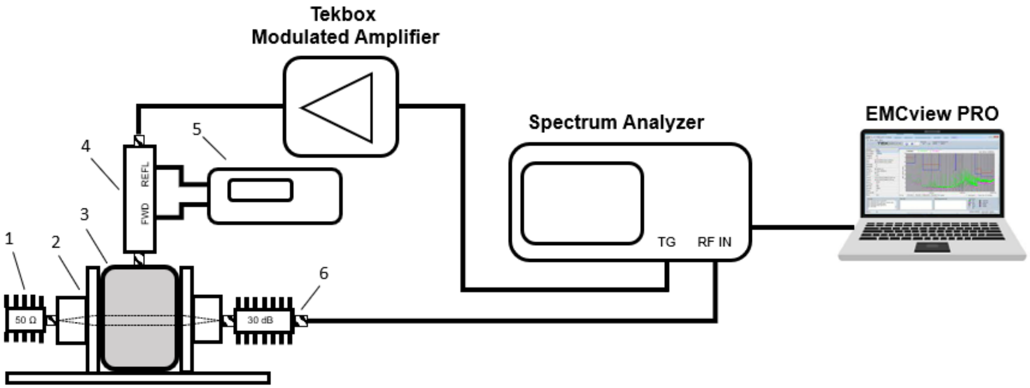
Figure 2: Current level test limits

传导抗扰度测试
ISO 11452-4，MIL-STD-461G，RTCA-DO-160C
校准/测试

校准方法

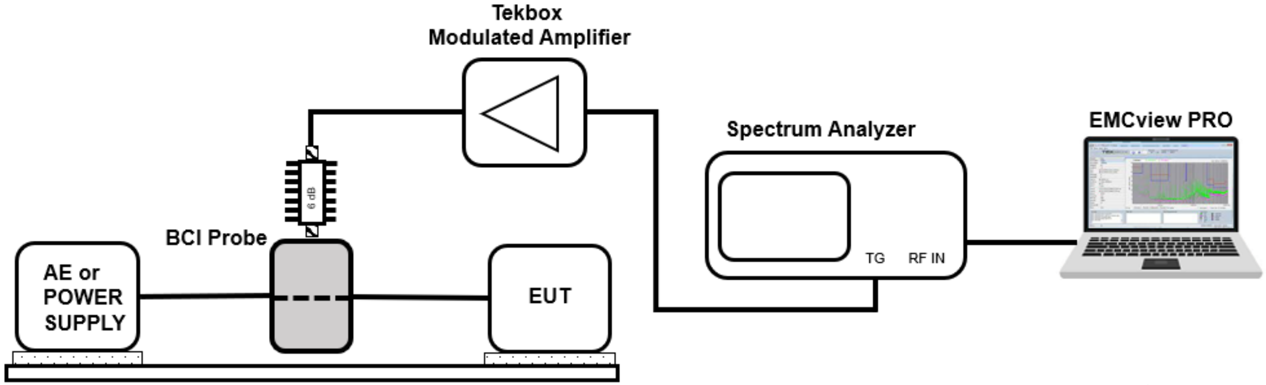
替代
闭环

替换、校准设置


Tekbox
Modulated Amplifier
Spectrum Analyzer
EMCview PRO
TG
RF IN
REFL
FWD
50 Ω
30 dB
1
2
3
4
5
6

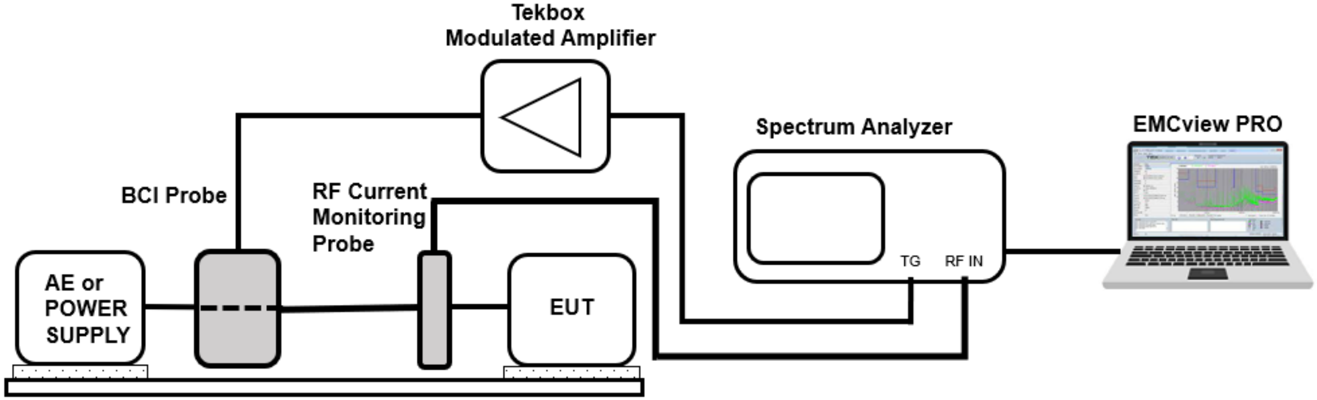
1) 50 Ohm termination 2) BCI probe calibration fixture 3) BCI probe 4) directional coupler 5) RF power meter or similar 6) 30 dB attenuator

替换、测试设置


Tekbox
Modulated Amplifier
Spectrum Analyzer
EMCview PRO
TG
RF IN
6 dB
BCI Probe
AE or
POWER
SUPPLY
EUT

传导抗扰度测试
ISO 11452-4，MIL-STD-461G，RTCA-DO-160C
校准/测试

闭环设置


Tekbox
Modulated Amplifier
Spectrum Analyzer
EMCview PRO
BCI Probe
RF Current
Monitoring
Probe
AE or
POWER
SUPPLY
EUT
TG
RF IN

电流探头正在监测注入的电流。EMCview控制TG电平以保持设定电流

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