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# 中华人民共和国石油天然气行业标准

**SY/T 5585—2009**

代替 SY/T 5585.1—1993, SY/T 5585.2—1993,

中文 /English

SY/T 5585.3—1993, SY/T 5585.4—1993

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## 地震数传电缆电参数测试方法

Test methods for seismic data transmission cable electrical parameters

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## 前 言

本标准对以下标准的内容进行了整合：

- SY/T 5585.1—1993《地震数传电缆电参数测试方法 特性阻抗和传播时间测试》；
- SY/T 5585.2—1993《地震数传电缆电参数测试方法 工作衰减测试》；
- SY/T 5585.3—1993《地震数传电缆电参数测试方法 串音衰减测试》；
- SY/T 5585.4—1993《地震数传电缆电参数测试方法 直流电阻、绝缘电阻、工作电容、仿真等测试》。

本标准代替以上标准，与被代替标准的主要区别包括：

- a) 本标准对比 SY/T 5585.1—1993：
  - 删除了关于传播时间的测试；
  - 对特性阻抗的测试删除了谐振法、脉冲法。
- b) 本标准对比 SY/T 5585.2—1993：工作衰减测试删除了电平差分法、脉冲测试法。
- c) 本标准对比 SY/T 5585.3—1993：串音衰减测试删除了电平差分法、脉冲测试法。
- d) 本标准对比 SY/T 5585.4—1993：删除了仿真测试。

本标准由石油仪器仪表专业标准化技术委员会提出并归口。

本标准主要起草单位：中国石油集团东方地球物理勘探有限责任公司西安物探装备分公司、河北赛赛尔俊峰物探装备有限公司和石油工业仪器仪表质量监督检验中心。

本标准主要起草人：韩晓泉、聂发君、何国信、汉泽西、张在陆、李佩昌、郭丽。

本标准所代替标准的历次版本发布情况为：

- SY/T 5585.1—1993；
- SY/T 5585.2—1993；
- SY/T 5585.3—1993；
- SY/T 5585.4—1993。

本标准以中文和英文两种文字出版，当英文和中文两种版本有歧义时，以中文版本为准。

# 地震数传电缆电参数测试方法

## 1 范围

本标准规定了陆用地震数传电缆电参数（特性阻抗、反射系数、工作衰减、串音衰减、直流电阻、绝缘电阻、工作电容）的测试方法。

本标准适用于地震数传电缆的电参数测试。

## 2 规范性引用文件

下列文件中的条款通过本标准的引用而成为本标准的条款。凡是注日期的引用文件，其随后所有的修改单（不包括勘误的内容）或修订版均不适用于本标准，然而，鼓励根据本标准达成协议的各方研究是否可使用这些文件的最新版本。凡是不注日期的引用文件，其最新版本适用于本标准。

GB/T 2421.1 电工电子产品环境试验 概述和指南

GB/T 3048.4 电线电缆电性能试验方法 第4部分：导体直流电阻试验

GB/T 3048.6 电线电缆电性能试验方法 绝缘电阻试验 电压—电流法

GB 5441.2 通信电缆试验方法 工作电容试验 电桥法

## 3 试样和环境条件要求

### 3.1 试样

所有的被测试的样长均应为  $100\text{m} \pm 1\text{m}$ 。在其他长度下测试的二次参数可以作为参考值。

### 3.2 环境条件

测试环境的正常试验大气条件按 GB/T 2421.1 的规定执行，其条件为：

- a) 温度： $20^{\circ}\text{C} \pm 3^{\circ}\text{C}$ 。
- b) 相对湿度：45%~75%。
- c) 大气压力：86kPa~106kPa。

## 4 测试方法

### 4.1 测试设备

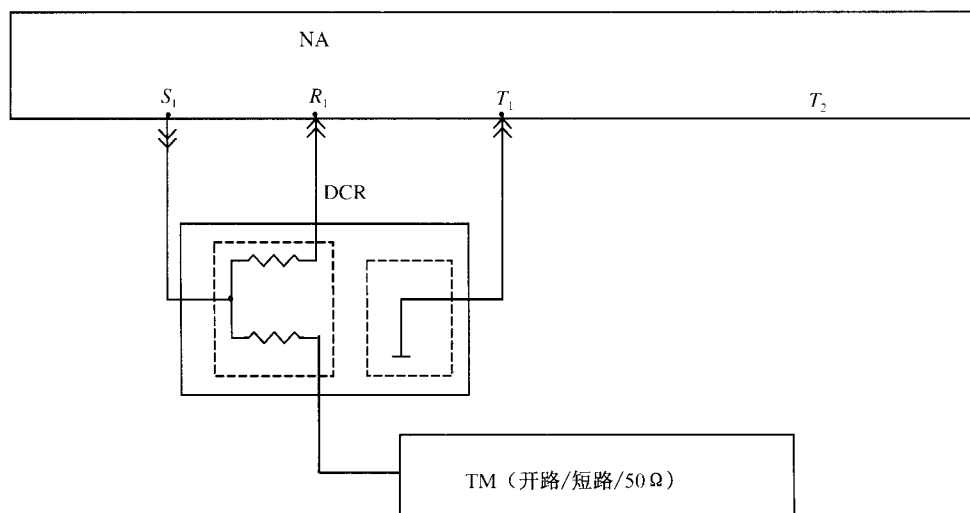
网络分析仪 HP4195A，HP4395A 或其他相当仪器，具有以下性能及指标：

- a) 频率范围：10Hz ~ 500MHz。
- b) 幅度范围： $-85\text{dB} \sim +20\text{dB}$ ；分辨率：0.001dB。
- c) 相位范围： $\pm 180^{\circ}$ ；分辨率： $0.01^{\circ}$ 。
- d) 具有计算机控制和处理系统。

### 4.2 特性阻抗

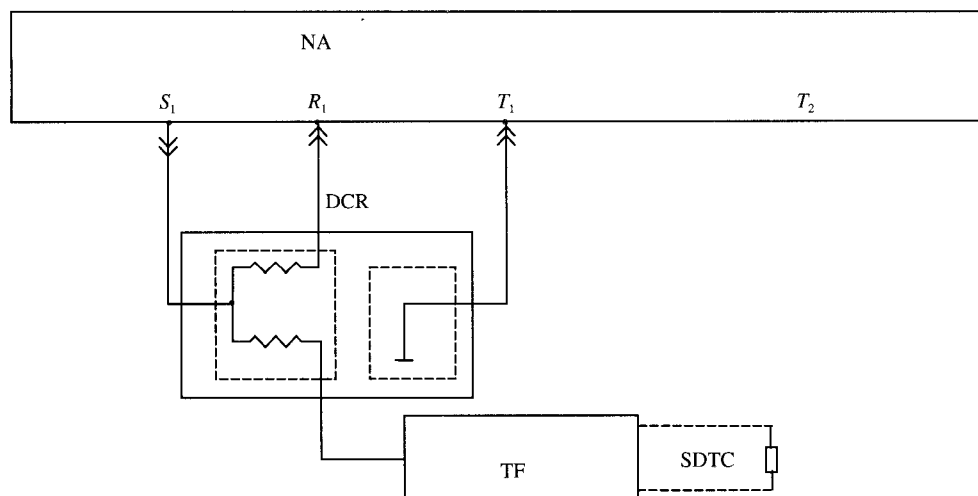
#### 4.2.1 测试原理框图

用网络分析仪进行地震数传电缆特性阻抗测试，首先要对测试系统校准，校准接线方式的原理框图如图 1 所示。经过计算并进行校准补偿后，即可进行特性阻抗测试，测试接线方式的原理框图如图 2 所示。



NA—网络分析仪；DCR—定向耦合器；TM—终端器（开路/短路/50Ω）

图1 网络分析仪测试特性阻抗校准接线图



NA—网络分析仪；DCR—定向耦合器；TF—测试台架；SDTC—地震数传电缆线对

图2 网络分析仪测试特性阻抗测试接线原理框图

#### 4.2.2 校准

用  $S$  参数功能在  $S_{11}(T_1/R_1)$  状态下，设定规定的起始频率和终止频率，并分别在 DCR 上输出端做开路、短路及加载  $(50 \pm 1) \Omega$  的终端进行校准测试；再安装测试固定架，并在测试架上利用短路弹簧进行开、短路测试并进行校准计算补偿。

#### 4.2.3 测试

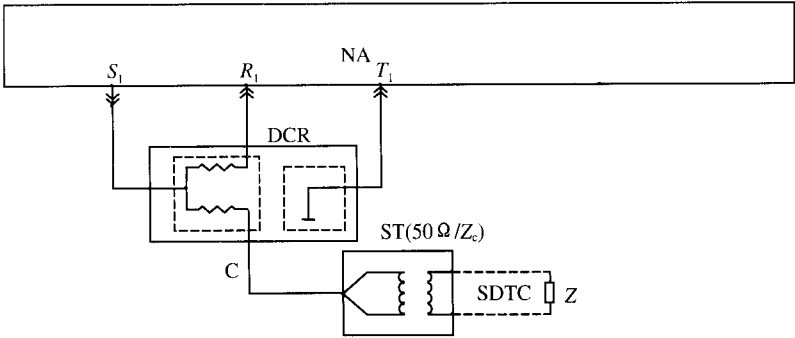
按图 2 连接测试系统。

在校准结束后，将被测电缆线对的一端接到测试台架上，在另一端分别进行开路/短路的情况下，触发测试系统的触发按钮，使用直角坐标分别显示出开路/短路的测试曲线图。用网络分析仪进行开路/短路曲线合成，显示出特性阻抗曲线图。可以选择显示平均特性阻抗值，也可以选择显示某一频率点的特性阻抗值。

4.3 反射系数

4.3.1 测试原理图

用网络分析仪测试地震数传电缆反射系数的接线方式的原理框图如图 3 所示。



NA—网络分析仪；DCR—定向耦合器（传输 / 反射测试匹配器）；ST—不对称—对称阻抗变量器；  
C—50Ω 同轴电缆；SDTC—地震数传电缆线对； $Z_c$ —被测电缆数传线对的特性阻抗值；Z—负载电阻

图 3 网络分析仪测试反射系数接线原理框图

4.3.2 校准

用 S 参数功能在  $S_{11}$  ( $T_1/R_1$ ) 状态下，分别设置规定的起始频率和终止频率，在阻抗变量器的次级分别进行开路、短路和负载电阻 Z 的校准测试。匹配电阻偏差应不超过电缆线对特性阻抗模数的  $\pm 5\%$ 。

4.3.3 测试

所测试的所有反射系数的模数应小于 0.09。测试的曲线图应采用极坐标方式显示的曲线均应在 0 ~ 0.09 的半径范围内。

4.3.4 计算

在求得被测电缆数传线对的特性阻抗  $Z_c$  后，也可以按式（1）计算反射系数。

$$\Gamma = \frac{Z - Z_c}{Z + Z_c} \dots\dots\dots (1)$$

式中：

- $\Gamma$ ——反射系数绝对值；
- $Z_c$ —— 特性阻抗；
- Z —— 电缆线对终端外接电阻，Ω。

4.4 工作衰减

4.4.1 测试原理框图

用网络分析仪测试地震数传电缆工作衰减的接线方式原理框图如图 4 所示。

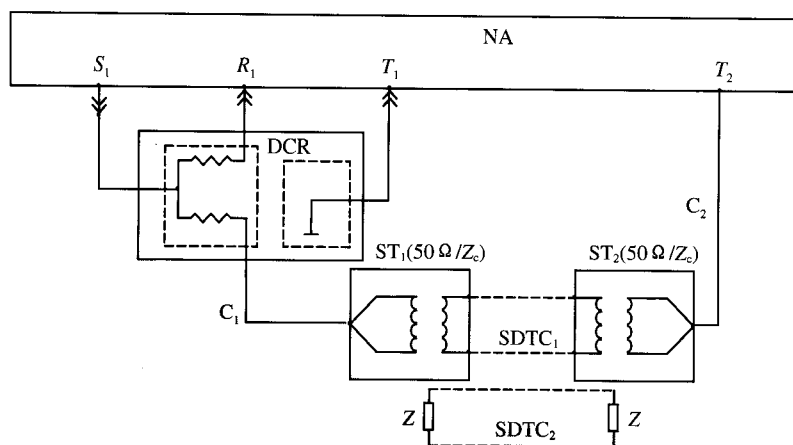
4.4.2 校准

用 S 参数功能在  $S_{21}$  ( $T_2/R_1$ ) 状态下，设定规定的起始频率和终止频率及分辨率宽度 1kHz 进行常规校准。在两个阻抗变量器（正常值：0dB，0°）之间使用的校准电缆线对长度不得超过 20cm。

4.4.3 测试

测试步骤如下：

- a) 校准结束后，将被测线对连接在两个阻抗变量器之间，其他数传线对接入与其相对应的特性阻抗模数相等的负载电阻，其偏差应不超过线对特性阻抗模数的  $\pm 5\%$ 。



NA—网络分析仪；DCR—定向耦合器（传输/反射测试匹配器）； $ST_1$ ， $ST_2$ —不对称—对称阻抗变量器； $C_1$ ， $C_2$ —50  $\Omega$  同轴电缆；SDTC<sub>1</sub>，SDTC<sub>2</sub>—地震数传电缆线对； $Z_c$ —被测电缆数传线对的特性阻抗值； $Z$ —负载电阻

图4 网络分析仪测试工作衰减接线原理框图

- b) 按动触发按钮开始测试，使用直角坐标显示测试曲线图，在图上读取相应频率点上的衰减值。或直接利用网络测试仪打印机直接打印测试曲线图。

#### 4.5 串音衰减

##### 4.5.1 测试近端串音衰减接线原理框图

用网络分析仪测试地震数传电缆串音衰减的近端串音衰减测试接线方式原理框图如图5所示。

##### 4.5.2 测试远端串音衰减接线原理框图

用网络分析仪测试地震数传电缆串音衰减的远端串音衰减测试接线方式原理框图如图6所示。

##### 4.5.3 校准

校准按4.4.2进行，测试系统在不接入被测电缆线对时，测试系统的串音衰减应优于被测电缆线对最小串音衰减值20dB以上（测试频率大于300kHz）。

##### 4.5.4 测试

测试步骤如下：

- 与主串、被串线对终端连接的负载电阻，应与相应的线对特性阻抗相等，其偏差应不超过线路特性阻抗模数的 $\pm 5\%$ 。
- 按图5接线测试近端串音衰减；按图6接线测试远端串音衰减。
- 按动触发按钮开始测试，使用直角坐标显示测试曲线图，使用仪器上MAX按钮在图上读取最大值（最小绝对值）的串音衰减值。或用网络分析仪打出近端串音衰减值 $B_0$ 和远端串音衰减值 $B_{01}$ 的数据和图件。

#### 4.6 直流电阻、绝缘电阻、工作电容

##### 4.6.1 直流电阻

按GB/T 3048.4规定的方法测试地震数传电缆的供电线对和数传线对的直流电阻。

##### 4.6.2 绝缘电阻

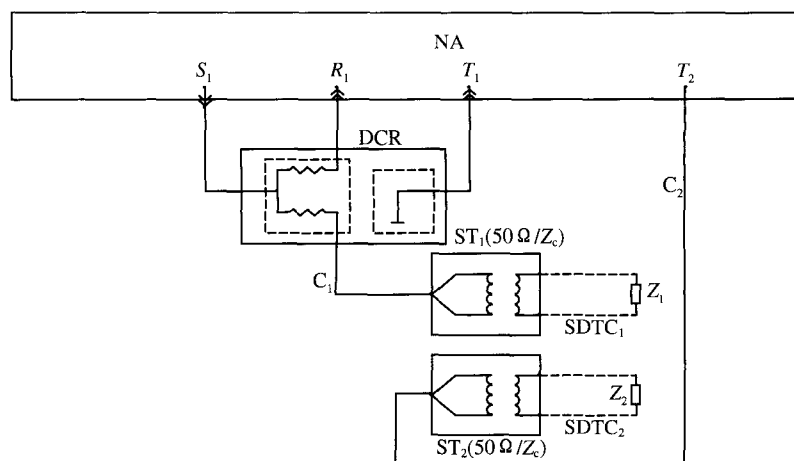
按GB/T 3048.6规定的方法测试地震数传电缆的绝缘电阻。

##### 4.6.3 工作电容

按GB 5441.2规定的方法测试地震数传电缆的工作电容。

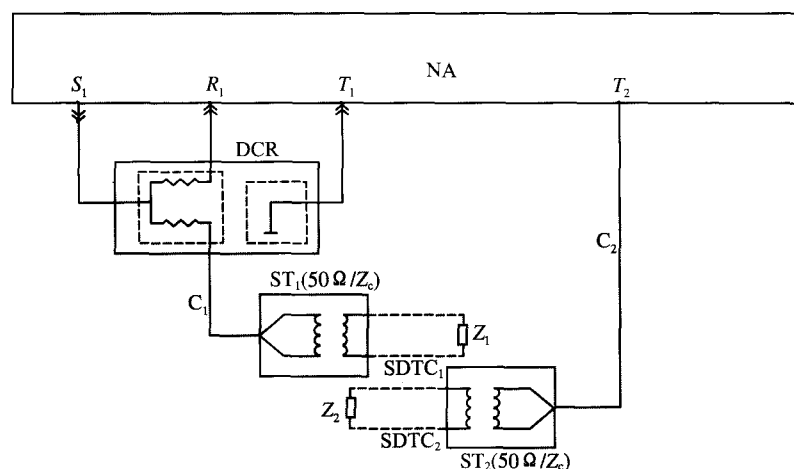
#### 5 注意事项

网络分析法测试时，分析计算机输出的图或辅以示波器观察，若被测线对有振荡时，则应停止对该电缆测试。



NA—网络分析仪；DCR—定向耦合器（传输/反射测试匹配器）； $ST_1$ 、 $ST_2$ —阻抗变量器； $C_1$ 、 $C_2$ — $50\Omega$  同轴电缆； $SDTC_1$ 、 $SDTC_2$ —地震数传电缆线对； $Z_c$ —被测电缆数传线对的特性阻抗值； $Z_1$ 、 $Z_2$ —负载电阻

图 5 网络分析仪测试近端串音衰减接线图



NA—网络分析仪；DCR—定向耦合器（传输/反射测试匹配器）； $ST_1$ 、 $ST_2$ —阻抗变量器； $C_1$ 、 $C_2$ — $50\Omega$  同轴电缆； $SDTC_1$ 、 $SDTC_2$ —地震数传电缆线对； $Z_c$ —被测电缆数传线对的特性阻抗值； $Z_1$ 、 $Z_2$ —负载电阻

图 6 网络分析仪测试远端串音衰减接线图





# **The People's Republic of China**

## **Standard of Petroleum and Natural Gas Industry**

**SY/T 5585—2009**

Replace SY/T 5585.1—1993, SY/T 5585.2—1993,  
SY/T 5585.3—1993, SY/T 5585.4—1993

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### **Test methods for seismic data transmission cable electrical parameters**

**Issue Date:12—01—2009**

**Implementation Date:05—01—2010**

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**Issued by the National Energy Administration,P.R.C.**

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## Foreword

This standard integrates the following :

- SY/T 5585.1—1993 *Test methods for seismic data transmission cable parameters—Characteristic impedance and propagation time* ;
- SY/T 5585.2—1993 *Test methods for seismic data transmission cable parameters—Operative attenuation measurement*;
- SY/T 5585.3—1993 *Test methods for seismic data transmission cable parameters—Crosstalk attenuation measurement*;
- SY/T 5585.4—1993 *Test methods for seismic data transmission cable parameters—Measurement of direct current resistance, insulation resistance, mutual capacitance and simulation etc.*

This standard will replace above four standards, the main differences between this standard and the above four standards being:

- a) Compared with SY/T 5585.1—1993:
  - This standard has removed the measurement of propagation time;
  - This standard has removed the resonance method and impulse method from the measurement of characteristic impedance.
- b) Compared with SY/T 5585.2—1993: this standard has removed the level difference method and impulse test method from operative attenuation measurement.
- c) Compared with SY/T 5585.3—1993: this standard

has removed the level difference method and impulse test method from crosstalk attenuation measurement.

- d) Compared with SY/T 5585.4—1993 : this standard has removed simulation measuring.

This standard was proposed by and under the jurisdiction of the Technical Committee of Petroleum Instrument Standardization.

This standard was drafted by Xian Geophysical Exploration Equipment, a subsidiary of Don Fang Geophysical Exploration Incorporated Company of China National Petroleum Corporation, Hebei Serceljunfeng Geophysical Prospecting Equipment Co., Ltd. and Petroleum Instrument Quality Surveillance and Test Center.

The main drafters of this standard are: Han Xiaoquan, Nie Fajun, He Guoxin, Han Zexi, Zhang Zailu, Li Peichang and Guo Li.

The standards replaced by this standard have been published in the following editions:

- SY/T 5585.1—1993;
- SY/T 5585.2—1993;
- SY/T 5585.3—1993;
- SY/T 5585.4—1993.

This standard is published in both Chinese and English. In the event of any discrepancy between the texts, the Chinese version shall prevail.

## Test methods for seismic data transmission cable electrical parameters

### 1 Scope

This standard specifies test methods for overland seismic data transmission cable parameters (characteristics impedance, reflection coefficient, operating attenuation, crosstalk attenuation, DC resistance, insulation resistance and operating capacitance).

This standard is applicable to measurement of seismic data transmission cable electrical parameters.

### 2 Normative references

The following normative documents contain provisions which, through reference in this standard, constitute provisions of this standard. For dated references, subsequent amendments to, or revisions of, any of these publications (exclude errata) do not apply. However, parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative documents referred to applies.

GB/T 2421.1 *Environmental testing—General and guidance*

GB/T 3048.4 *Test methods for determining electrical properties of electric cable and wire—Part 4: Measurement of DC resistance of conductors*

GB/T 3048.6 *Test methods for determining electrical properties of electric cable and wire Determining insulation resistance Voltmeter—ammeter methods*

GB/T 5441.2 *Test methods for communication cable—Capacitance test—Bridge method*

### 3 Measuring samples and environmental condition requirements

#### 3.1 Measuring samples

All measuring samples shall be  $100\text{m} \pm 1\text{m}$  long. Measurements made at other length is of reference value.

#### 3.2 Environmental conditions

The normal atmospheric conditions of the measurement environment are in accordance with the regulations of GB/T 2421.1, as following :

- a) Temperature:  $20^{\circ}\text{C} \pm 3^{\circ}\text{C}$  .
- b) Relative humidity: 45% ~ 75% .
- c) Atmospheric pressure: 86 kPa~106 kPa.

### 4 Measurement methods

#### 4.1 Measurement equipment

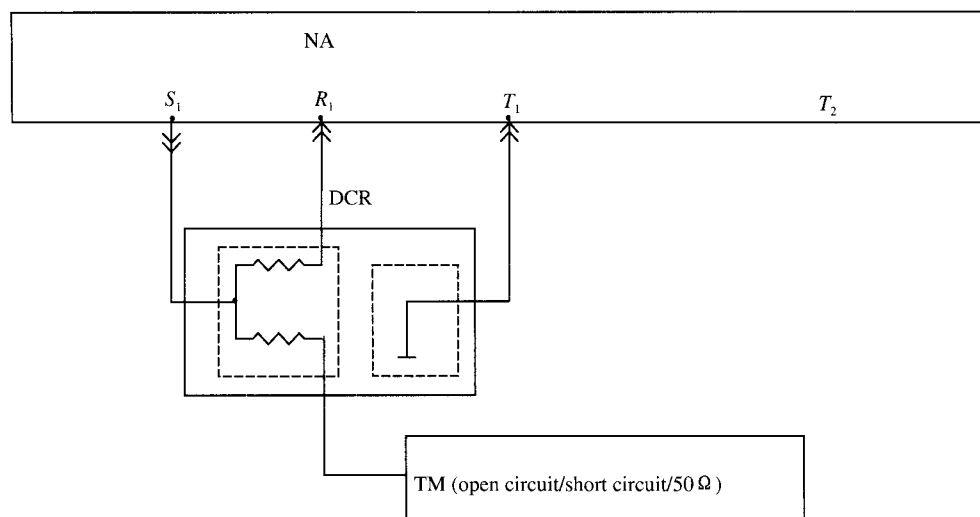
Network analyzers HP4195A, HP4395A or other equivalent instruments, having such performances and specifications as follows:

- a) Frequency range: 10Hz ~ 500M Hz.
- b) Amplitude range: -85dB ~ +20dB; resolution: 0.001dB.
- c) Phase range:  $\pm 180^{\circ}$  ; resolution:  $0.01^{\circ}$  .
- d) Computer control and processing system.

#### 4.2 Characteristic impedance

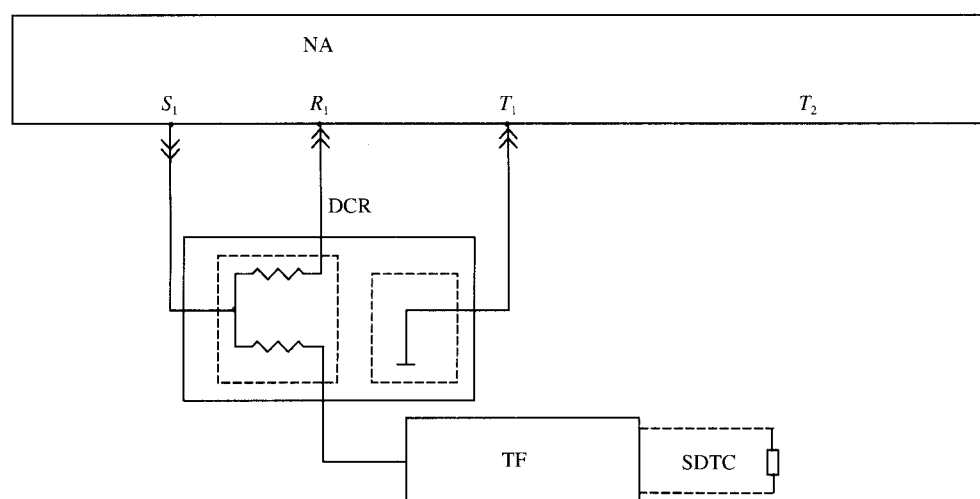
##### 4.2.1 Measurement principle

A network analyzer is used to measure the characteristic impedance of seismic data transmission cables, First the measuring system is calibrated the wiring diagram as shown in Figure 1. After calibration the seismic data transmission cable pairs can be measured the wiring diagram as shown in Figure 2.



NA—Network analyzer; DCR—Directional coupler; TM—Terminator (open circuit/short circuit/50 Ω)

**Figure 1 Network analyzer measuring characteristic impedance calibration wiring diagram**



NA—Network analyzer; DCR—Directional coupler; TF—Testing fixture; SDTC—Seismic data transmission cable pairs

**Figure 2 Network analyzer characteristic impedance measurement wiring diagram**

#### 4.2.2 Calibration

Connect the measuring system as shown in Figure 1. The specified start frequency and ending frequency are respectively set using the  $S$  parameter function under  $S_{11}$  ( $T_1/R_1$ ) state. Calibration measurements are conducted with open circuit, short circuit and loaded  $(50 \pm 1) \Omega$  terminators attached at terminals of DCR. Next the special test fixture bracket is installed, and open and short circuit testing and calibration calculation compensation are conducted using short

circuit springs on the measuring bench.

#### 4.2.3 Measurement

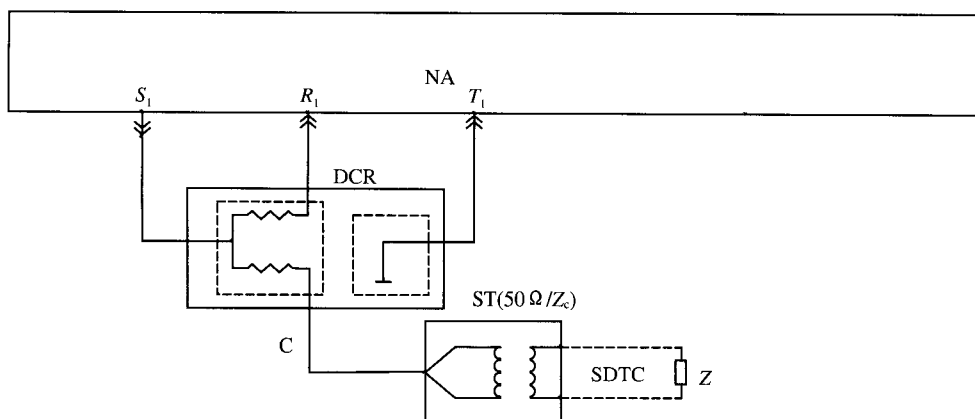
Connect the measuring system as shown in Figure 2. After calibration, one end of the tested cable pairs is connected to the test fixture; under the condition of respectively open and short circuit of the other end, the trigger button of the tester is activated, and the testing graph of open circuit and short circuit is respectively plotted using rectangular coordinates. The network analyzer synthesizes the characteristic

impedance graph from the open and short circuit curves. Characteristic impedance can be shown as an average over frequency range, or against a specific frequency point.

### 4.3 Reflection coefficient

#### 4.3.1 Test schematic diagram

The wiring diagram for testing the reflection coefficient of seismic data transmission cables using the network analyzer is shown in Figure 3.



NA—Network analyzer; DCR—Directional coupler (transmission/reflection testing matcher);

ST—Asymmetrical-symmetric impedance transformer; C—50  $\Omega$  coaxial cables; SDTC—Seismic data transmission cable pairs;

$Z_c$ —The characteristic impedance value of the tested data transmission cable pairs; Z—Load resistance

Figure 3 Wiring diagram of reflection coefficient testing using the network analyzer

#### 4.3.2 Calibration

The specified start frequency and ending frequency are respectively set using the  $S$  parameter function under  $S_{11}$  ( $T_1/R_1$ ) state, calibrations are performed with open circuit, short circuit and loaded matching resistance  $Z$  connected at the secondary winding of the impedance transformer. The tolerance of the matching resistance shall not exceed  $\pm 5\%$  of the characteristic impedance modulus of tested cable pairs.

#### 4.3.3 Testing

The modulus of all tested reflection coefficients shall be less than 0.09. Plotted using polar coordinates, all curves shall be within the range of 0~0.09 in radius.

#### 4.3.4 Calculation

Knowing the characteristic impedance  $Z_c$  of the tested data transmission cable pairs, the reflection coefficient can also be calculated from formula (1):

$$\Gamma = \frac{Z - Z_c}{Z + Z_c} \quad \dots\dots\dots (1)$$

Where:

$\Gamma$ —The absolute value of reflection coefficient;

$Z_c$ —Characteristic impedance;

$Z$ —The external resistance of cable pair terminal,  $\Omega$ .

### 4.4 Operative attenuation

#### 4.4.1 Testing principle block diagram

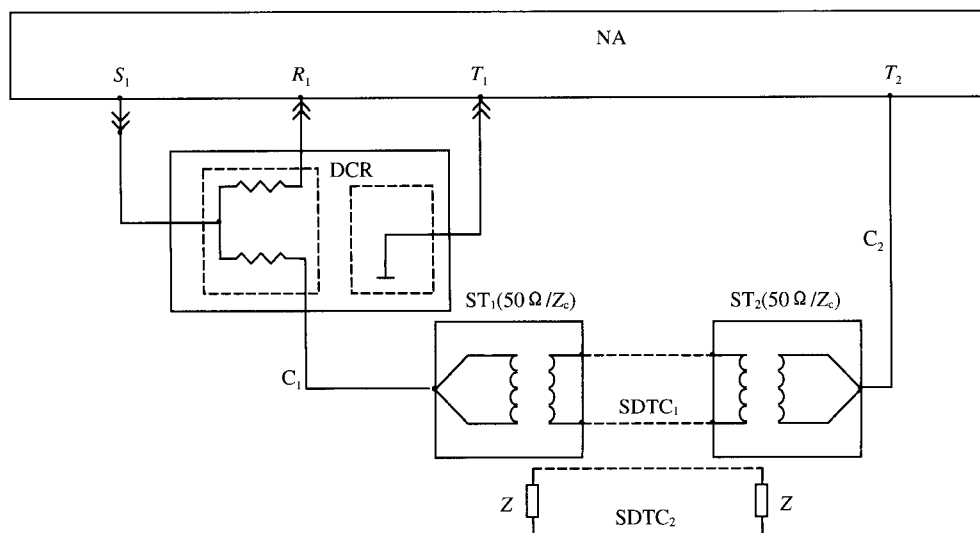
The wiring diagram for testing the operative attenuation of seismic data transmission cables using the network analyzer is shown in Figure 4.

#### 4.4.2 Calibration

Under  $S_{21}$  ( $T_2/R_1$ ) state, the specified start frequency, ending frequency and resolution width of 1kHz are set using the  $S$  parameter function to conduct conventional calibration. The length of the calibration cable pairs used between the two impedance transformers (normal value: 0dB,  $0^\circ$ ) shall not exceed 20cm.

#### 4.4.3 Testing

The testing procedures are as following:



NA—Network analyzer; DCR—Directional coupler (transmission/reflection testing matcher);  $ST_1$ ,  $ST_2$ —Asymmetrical-symmetric impedance transformers;  $C_1$ ,  $C_2$ —50  $\Omega$  coaxial cables;  $SDTC_1$ ,  $SDTC_2$ —Seismic data transmission cable pairs;  $Z_c$ —The characteristic impedance value of the tested data transmission cable pairs;  $Z$ —Load resistance

**Figure 4 Wiring diagram of operative attenuation testing using the network analyzer**

- a) After calibration, the cable pairs under test is connected between the two impedance transformers; other data transmission cable pairs are connected to the load resistances of equal characteristic impedance modulus, the tolerance of which shall not exceed  $\pm 5\%$  of the characteristic impedance modulus of cable pairs.
- b) Press the trigger button to start testing, use rectangular coordinates to plot testing graphs and read the attenuation value at the corresponding frequency point on the graphs, or the network tester printer can be used to print the testing curve graphs.

## 4.5 Crosstalk attenuation

### 4.5.1 Near-end crosstalk attenuation wiring diagram

The test setup for measuring near-end crosstalk attenuation of seismic data transmission cables using network analyzer is shown in Figure 5.

### 4.5.2 Remote-end crosstalk attenuation wiring principle block diagram

The test setup for measuring remote-end crosstalk attenuation of seismic data transmission cables using the network analyzer is shown in Figure 6.

### 4.5.3 Calibration

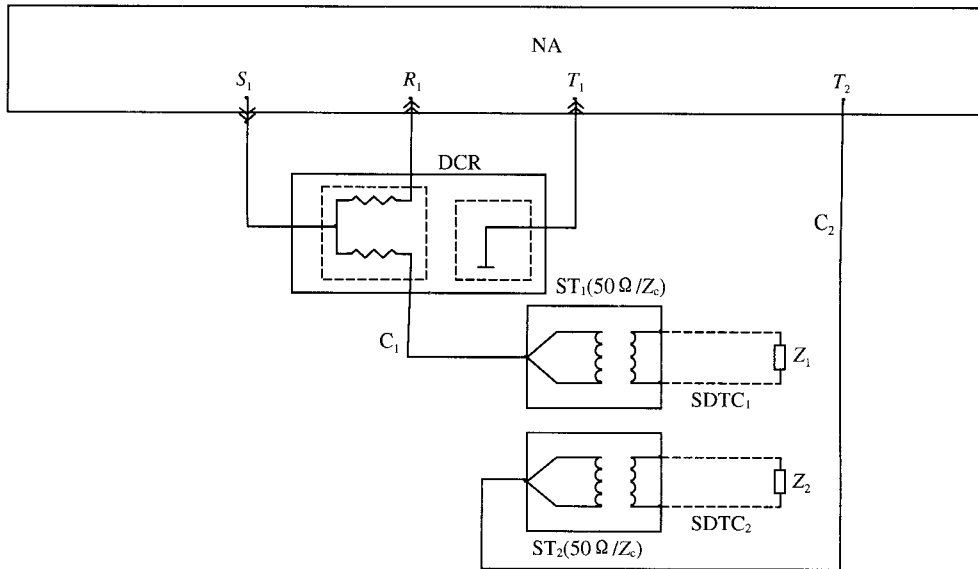
The same as 4.4.2. When the testing system is not

connected to the tested cable pairs, the crosstalk attenuation of the testing system shall be 20dB better than the minimum crosstalk attenuation value (testing frequency higher than 300kHz) of the tested cable pairs.

### 4.5.4 Testing

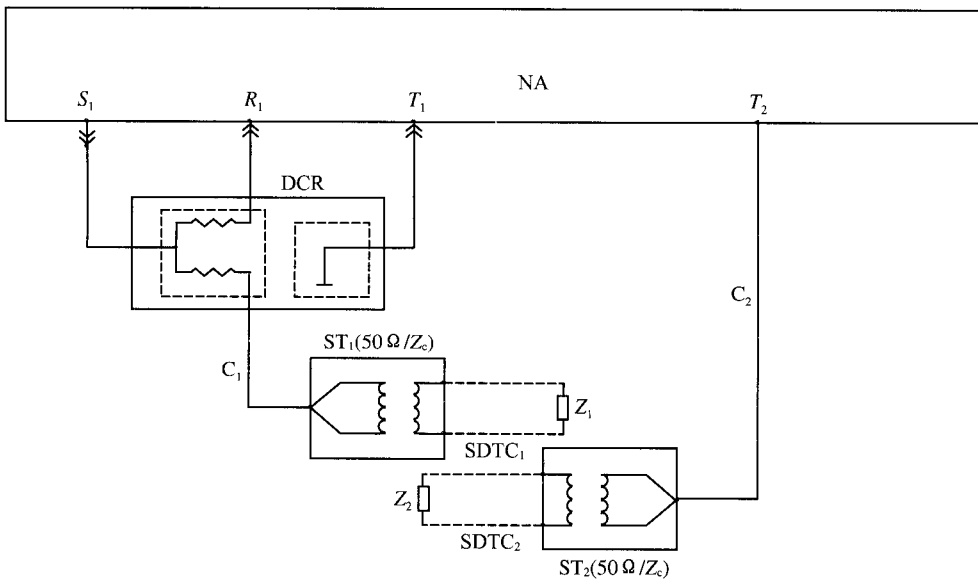
The testing procedures are as following:

- a) The load resistance connected with the terminal of the main crosstalk and slave crosstalk cable pairs shall be equal to the corresponding characteristic impedance, and the tolerance shall not exceed  $\pm 5\%$  of the line characteristic impedance modulus.
- b) Test the near-end crosstalk attenuation as the wiring in Figure 5; test the remote-end crosstalk attenuation as the wiring in Figure 6.
- c) Press the trigger button to start testing, use rectangular coordinates to show testing graphs, and read the maximum (minimum absolute value) crosstalk attenuation value on the graphs using the MAX button on the instrument. Alternatively use the network analyzer to print out the data and drawings of the near-end crosstalk attenuation value  $B_0$  and the remote-end crosstalk attenuation value  $B_{01}$ .



NA—Network analyzer; DCR—Directional coupler (transmission/reflection testing matcher); ST<sub>1</sub>, ST<sub>2</sub>—Impedance transformers; C<sub>1</sub>, C<sub>2</sub>—50 Ω coaxial cables; SDTC<sub>1</sub>, SDTC<sub>2</sub>—Seismic data transmission cable pairs; Z<sub>c</sub>—The characteristic impedance value of the tested data transmission cable pairs; Z<sub>1</sub>, Z<sub>2</sub>—Load resistances

**Figure 5** Wiring diagram of near-end crosstalk attenuation testing using the network analyzer



NA—Network analyzer; DCR—Directional coupler (transmission/reflection testing matcher); ST<sub>1</sub>, ST<sub>2</sub>—Impedance transformers; C<sub>1</sub>, C<sub>2</sub>—50 Ω coaxial cables; SDTC<sub>1</sub>, SDTC<sub>2</sub>—Seismic data transmission cable pairs; Z<sub>c</sub>—The characteristic impedance value of the tested data transmission cable pairs; Z<sub>1</sub>, Z<sub>2</sub>—Load resistances

**Figure 6** Wiring diagram of remote-end crosstalk attenuation testing using the network analyzer



#### **4.6 DC resistance, insulation resistance and mutual capacitance**

##### **4.6.1 DC resistance**

The DC resistance of the power supply cable pairs and seismic data transmission cable pairs is tested in accordance with the method specified in the national standard GB/T 3048.4.

##### **4.6.2 Insulation resistance**

The insulation resistance of the seismic data transmission cable pairs is tested in accordance with the method specified in the national standard GB/T 3048.6.

##### **4.6.3 Mutual capacitance**

The mutual capacitance of the seismic data transmission cable pairs is tested in accordance with the method specified in the national standard GB 5441.2.

#### **5 Precaution**

During testing using the network analytical method, computer output graphs shall be analyzed, optionally supplemented with oscilloscope monitoring, to detect oscillation, whereupon the testing of the cable pairs shall be stopped.