Application Note

Fast Control Port with MDR 26 Pin Connector

Purpose

For fast, time critical settings like frequency changes the measurement device can be controlled over an additional port. This application note explains the usage of the Fast Control Port.

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Introduction

For fast, time critical settings like frequency changes the device can be controlled over the Fast Control Port (FCP). It is a parallel port that can be operated in either '8-bit Mode' or '16-bit Mode'. If activated, frequency and/or amplitude of the device are controlled by the FCP. With FCP, memory is addressed and filled with frequency or amplitude information.
To enable and configure the communication over FCP, the device has to be configured in advance over SCPI.

Configuring the FCP

To select the operating mode of the Fast Control Port, the FCP has to be configured with a SCPI command:

[:SOURce]:FCPort:MODE 8|8B|8Bits|16|16B|16Bits

Configures the operation mode of the FCP.

*RST value: 16

Further related commands are documented in the Programmer's Manual[1].

8-bit Mode

'8-bit Mode' is limited to frequency control of one RF channel or to a common frequency on several channels. The frequency can either be selected by the index of a pre-defined frequency list or by sending the complete frequency word. On multi-channel devices, it is not possible to operate one channel with a list of frequencies and the other with a frequency word.

Setting the RF frequency and amplitude

The RF output signal can be configured via the FCP with

- The frequency word (FW). It is 48 bits wide, unsigned and is calculated as *FW = Frequency in Hz * 256.*
- The amplitude word (AW). It is 16 bits wide, signed (two's complement) and is calculated as *AW = Amplitude in dBm * 127.*

8-bit mode is limited to only one set of one frequency and one amplitude word. All channels with FCP enabled will use the same set.
However, frequency vs. amplitude word may be used individually: one channel (e.g. 3) can be under FCP amplitude control, while another channel (e.g. 2) is under FCP frequency control.

The signal generator has to be setup to be controlled by FCP with SCPI commands:

[:SOURce#]:FCPort:CONTrol:FREQuency ON|OFF|1|0

Enables or disables FCP frequency control on the specified RF channel
*RST value: OFF

[:SOURce#]:FCPort:CONTrol:AMPLitude ON|OFF|1|0

Enables or disables FCP amplitude control on the specified RF channel
*RST value: OFF

Complete SCPI command sequence for frequency mode:

SOUR<x>	Select the RF output
OUTP ON	Enables RF output
FREQ <x>	Sets initial RF output frequency
POW <x>	Sets RF output power
FCP:MODE 8	Sets FCP to 8-bit Mode
FCP:CONT:FREQ ON	Enables FCP frequency control

For amplitude mode, modify the last command:

FCP:CONT:AMPL ON	Enables FCP amplitude control

Both modes can be combined to full frequency and amplitude control:

FCP:CONT:FREQ ON;AMPL ON	Enables combined FCP frequency and amplitude control

The Frequency Word (FW) is written sequentially to address 0 to 11. Writing bit 47 (MSB) of the FW triggers the processing and updates of the RF output signal that is
*RF Frequency = FW value * 1 Hz / 256.*

The Amplitude Word (AW) is written sequentially to address 12 to 15. Writing bit 15 (MSB) of the AW triggers the processing and updates of the RF output signal that is
*RF Amplitude = AW value * 1 dBm / 128.*

In combined frequency and amplitude mode, writing the MSB of both words (global bit 63 = AW bit 15) triggers the update. This ensures simultaneous frequency and amplitude update at the RF output.

Address	Data
0	FW (frequency word) bits [3...0]
1	FW (frequency word) bits [7...4]
2	FW (frequency word) bits [11...8]
3	FW (frequency word) bits [15...12]
4	FW (frequency word) bits [19...16]
5	FW (frequency word) bits [23...20]
6	FW (frequency word) bits [27...24]
7	FW (frequency word) bits [31...28]
8	FW (frequency word) bits [35...32]
9	FW (frequency word) bits [39...36]
10	FW (frequency word) bits [43...40]
11	FW (frequency word) bits [47...44]
12	AW (amplitude word) bits [3…0]
13	AW (amplitude word) bits [7…4]
14	AW (amplitude word) bits [11…8]
15	AW (amplitude word) bits [15…12]

Timing

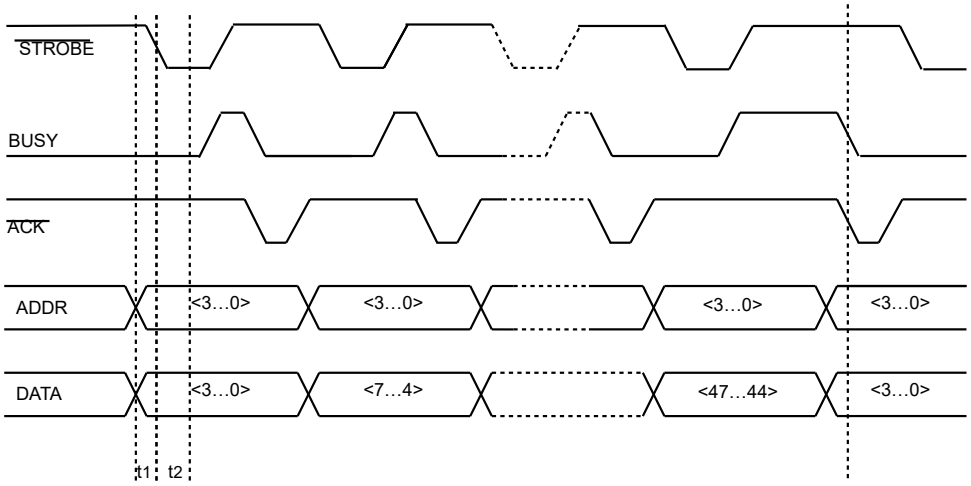

Figure 1 Programming of FW over FCP in '8-bit Mode'

Address and data are transferred at the same time. The signal generator reads the data upon a falling edge on the strobe line. The signal generator confirms the received data with ACK and informs the controller by the BUSY signal while processing the information.

Signals:	Address A<3..0>, Data D<3..0>, STROBE, ACK, BUSY
Setup-time t1:	> -10 ns
Hold-time t2:	> 60 ns
Strobe high time:	> 60 ns
Strobe fall to busy rise:	85…105 ns
Strobe fall to /ACK fall:	145…165 ns
Busy high time:	> 55 ns (typically 55…65 ns)
/ACK low time:	> 55 ns (typically 55…65 ns)
/ACK rise to next strobe fall:	> 0 ns

SCPI & FCP Example

This is a SCPI example to set the RF output frequency of RF output 2 on a multi-channel system:

***RST**	Reset device
OUTP2 ON	Enables RF output 2
POW 5	Sets RF output power to 5 dBm
FCP:MODE 8	set FCP to 8-bit Mode
SOUR2:FCP:CONT:FREQ ON	Enables FCP on RF output 2
***OPC?**	Check if operation is completed

After successfully configuring RF channel 2, writing FW 256'000'000'000 to the FCP leads to a 1 GHz RF signal.

To provide the same frequency on multiple channels, FCP:CONT:FREQ ON has to be enabled on each channel.

Selecting pre-defined RF Frequency

In this mode the device plays points from a pre-defined list of frequency settings with max. 20'000 entries. It is similar to a list sweep but with the FCP selecting the pre-defined frequency.

8-bit mode is limited to only one list word. All channels with FCP enabled will use the same list word.
However, the frequency list of each channel can be configured individually: e.g. point 1 can be 1 GHz for channel 1 but 2 GHz for channel 2.

The signal generator has to be setup to be controlled by FCP with a SCPI command:

[:SOURce]:FCPort:CONTrol:LIST ON|OFF|1|0

Enables or disables FCP on the specified RF channel

*RST value: OFF

Complete SCPI command sequence to set up RF output to play selected frequency point:

SOUR <channel>	
OUTP ON	Enables RF output
POW <x>	Sets RF output power
LIST:FREQ <f1>,<f2>,<f3>,…,<fn>	Defines list of frequency settings
FCP:MODE 8	Sets FCP to 8-bit Mode
FCP:CONT:LIST ON	Enables FCP control

To select a pre-defined frequency, a 16-bit data list word (LW) has to be written to address 0 to 3. Writing bit 15 (MSB) triggers the processing and update of the RF output signal.

Address	Data
0	LW (list word) bits [3...0]
1	LW (list word) bits [7...4]
2	LW (list word) bits [11...8]
3	LW (list word) bits [15...12]

Writing 1 to the list word (LW) plays <f1>, LW = 2 plays <f2> etc.

Timing

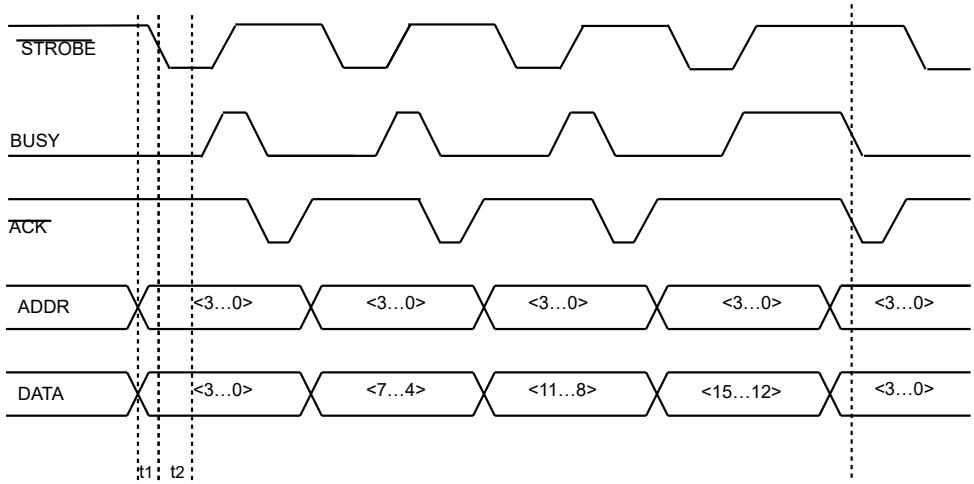

Figure 2 Sending list word over FCP in '8-bit Mode'

Address and data are transferred at the same time. The signal generator reads the data upon a falling edge on the strobe line. The signal generator confirms the received data with ACK and informs the controller by the BUSY signal while processing the information.

Setup-time t1:	> -10 ns
Hold-time t2:	> 60 ns
Strobe high time:	> 60 ns
Strobe fall to busy rise:	85…105 ns
Strobe fall to /ACK fall:	145…165 ns
Busy high time:	> 55 ns (typically 55…65 ns)
/ACK low time:	> 55 ns (typically 55…65 ns)
/ACK rise to next strobe fall:	> 0 ns

SCPI & FCP Example

This is a SCPI example to set up RF output 1 and RF output 3 on a multi-channel system to play selected frequency point:

***RST**	Resets device
OUTP1 ON	Enables RF output 1
OUTP3 ON	Enables RF output 3
POW1 5	Sets RF output power to 5 dBm
POW3 7	Sets RF output power to 7 dBm
SOUR1:LIST:FREQ 1 GHz,1.5 GHz,2 GHz	Defines list of frequencies
SOUR3:LIST:FREQ 1.2 GHz,1.25 GHz,1.3 GHz	Defines list of frequencies
FCP:MODE 8	Sets FCP to 8-bit Mode
SOUR1:FCP:CONT:LIST ON	Enables FCP on RF output 1
SOUR3:FCP:CONT:LIST ON	Enables FCP on RF output 3
***OPC?**	Checks if operation is completed

After successfully configuring RF output 1 and 3, writing 1 to the list word (LW) over the FCP, would simultaneously play

- 1 GHz on RF output 1 with output power of 5 dBm
- 1.2 GHz on RF output 3 with output power of 7 dBm

16-bit Mode

The '16-bit Mode' extends the '8-bit Mode' with multi-channel support. The frequency can either be selected by the index of a pre-defined frequency list or by sending the complete frequency word. On a multi-channel system, it is possible to operate each channel individually with a frequency list, the frequency or the amplitude word.

Setting the RF Frequency and Amplitude

The RF output signal can be configured via the FCP with

- The frequency word (FW). It is 48 bits wide, unsigned and is calculated as *FW = Frequency in Hz * 256.*
- The amplitude word (AW). It is 16 bits wide, signed (two's complement) and is calculated as *AW = Amplitude in dBm * 127.*

The signal generator has to be setup to be controlled by FCP with SCPI commands:

[:SOURce]:FCPort:CONTrol:FREQuency ON|OFF|1|0

Enables or disables FCP to set frequency word on the specified RF channel
*RST value: OFF

[:SOURce#]:FCPort:CONTrol:AMPLitude ON|OFF|1|0

Enables or disables FCP amplitude control on the specified RF channel
*RST value: OFF

Complete SCPI command sequence for frequency mode:

SOUR<x>	Select the RF output
OUTP ON	Enables RF output
FREQ <x>	Sets initial RF output frequency
POW <x>	Sets RF output power
FCP:MODE 16	Sets FCP to 16-bit Mode
FCP:CONT:FREQ ON	Enables FCP control

For amplitude mode, modify the last command:

FCP:CONT:AMPL ON	Enables FCP amplitude control

Both modes can be combined to full frequency and amplitude control:

FCP:CONT:FREQ ON;AMPL ON	Enables combined FCP frequency and amplitude control

The Frequency Word (FW) is written sequentially to address 0 to 5. Writing bit 47 (MSB) of the FW triggers the processing and updates of the RF output signal that is
*RF Frequency = FW value * 1 Hz / 256.*

The Amplitude Word (AW) is written sequentially to address 6 to 7. Writing bit 15 (MSB) of the AW triggers the processing and updates of the RF output signal that is
*RF Amplitude = AW value * 1 dBm / 128.*

In combined frequency and amplitude mode, writing the MSB of both words (global bit 63 = AW bit 15) triggers the update. This ensures simultaneous frequency and amplitude update at the RF output.

RF Channel	Address	Data
1	0	FW (frequency word) bits [7...0]
1	1	FW (frequency word) bits [15...8]
1	2	FW (frequency word) bits [23...16]
1	3	FW (frequency word) bits [31...24]
1	4	FW (frequency word) bits [39...32]
1	5	FW (frequency word) bits [47...40]
1	6	AW (amplitude word) bits [7...0]
1	7	AW (amplitude word) bits [15...8]
2	16…21	FW (frequency word)
2	22…23	AW (amplitude word)
3	32…37	FW (frequency word)
3	38…39	AW (Amplitude word)
4	48…53	FW (frequency word)
4	54…55	AW (amplitude word)

Timing

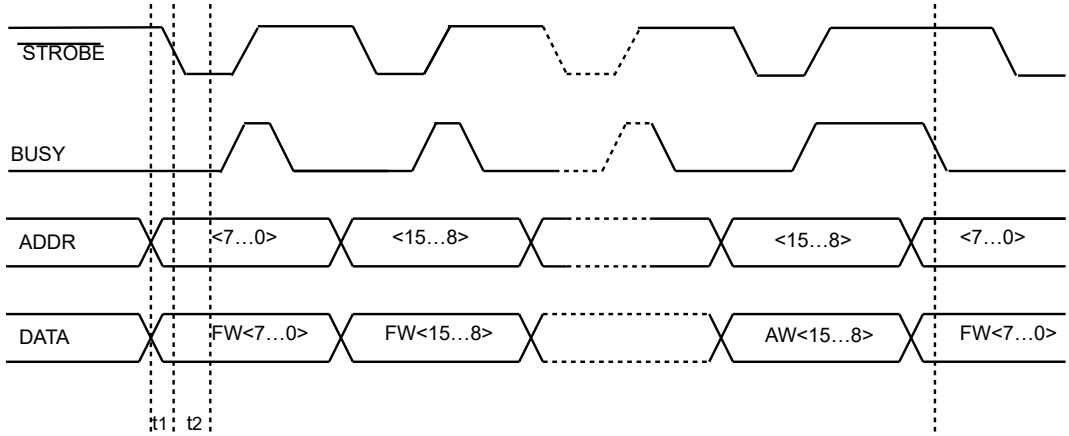

Figure 3 Programming of FW with FCP in '16-bit Mode'

Address and data are transferred at the same time. The signal generator reads the data upon a falling edge on the strobe line. The signal generator informs the controller by the BUSY signal while processing the information. In 16-bit mode there is no /ACK signal, however the BUSY signal going high and low can serve as a transfer accepted acknowledge.

Signals:	Address A<7..0>, Data D<7..0>, STROBE, BUSY
Setup-time t1:	> -10 ns
Hold-time t2:	> 60 ns
Strobe high time:	> 60 ns
Strobe fall to busy rise:	85…105 ns
Busy high time:	> 55 ns (typically 55…65 ns)
Busy fall to next strobe fall:	> 60 ns

SCPI & FCP example

This is a SCPI example to set the RF output frequency of RF output 2 on a multi-channel system:

***RST**	Reset device
OUTP1 ON	Enables RF output 1
OUTP3 ON	Enables RF output 3
POW1 5	Sets RF output power to 5 dBm
POW3 7	Sets RF output power to 7 dBm
FCP:MODE 16	Sets FCP to 16-bit Mode
SOUR1:FCP:CONT:FREQ ON	Enables FCP on RF output 1
SOUR3:FCP:CONT:FREQ ON	Enables FCP on RF output 3
***OPC?**	Check if operation is completed

After successfully configuring RF channel 1 and 3, writing FW 256’000’000’000 to the FCP leads with the preliminary firmware to

- 1 GHz on RF output 1 with output power of 5 dBm
- 1 GHz on RF output 3 with output power of 7 dBm

With FW revision > 0.152, for each RF channel an individual frequency and amplitude word can be set.

Selecting pre-defined RF Frequency

In this mode the device plays points from a pre-defined list of frequency settings with max. 20'000 entries. It is similar to a list sweep but with the FCP selecting the pre-defined frequency.

The signal generator has to be setup to be controlled by FCP with a SCPI command:

[:SOURce]:FCPort:CONTrol:LIST ON|OFF|1|0

Enables or disables FCP on the specified RF channel

*RST value: OFF

Complete SCPI command sequence to set up RF output to play selected frequency point:

SOUR <channel>	
OUTP ON	Enables RF output
POW <x>	Sets RF output power
LIST:FREQ <f1>,<f2>,<f3>,…,<fn>	Defines list of frequency settings
FCP:MODE 16	Sets FCP to 16-bit Mode
FCP:CONT:LIST ON	Enables FCP control

For each RF channel a 16-bit data list word (LW) has to be written to address 0 to 1 to select the pre-defined frequencies (see table below). Writing bit 15 (MSB) of a list word 1 triggers the processing and update of the corresponding channel's RF output signal.

RF channel	Address	Data
1	0	LW (list word) bits [7...0]
1	1	LW (list word) bits [15...8]
2	16	LW (list word) bits [7...0]
2	17	LW (list word) bits [15...8]
3	32	LW (list word) bits [7...0]
3	33	LW (list word) bits [15...8]
4	48	LW (list word) bits [7...0]
4	49	LW (list word) bits [15...8]

Writing 1 to the list word (LW) plays <f1>, LW = 2 plays <f2> etc.

Timing

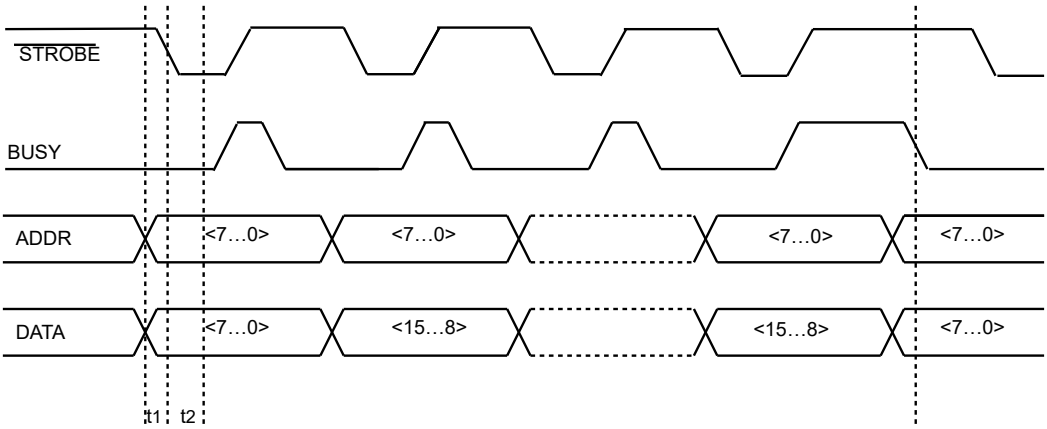

Figure 4 Programming of frequency list over FCP in '16-bit Mode'

Address and data are transferred at the same time. The signal generator reads the data upon a falling edge on the strobe line. The signal generator informs the controller by the BUSY signal while processing the information. In 16-bit mode there is no /ACK signal, however the BUSY signal going high and low can serve as a transfer accepted acknowledge.

Signals**:**	Address A<7..0>, Data D<7..0>, STROBE, BUSY
Setup-time t1:	> -10 ns
Hold-time t2:	> 60 ns
Strobe high time:	> 60 ns
Strobe fall to busy rise:	85…105 ns
Busy high time:	> 55 ns (typically 55…65 ns)
Busy fall to next strobe fall:	> 60 ns

SCPI & FCP Example

This is a SCPI example to set up RF output 1 and RF output 3 on a multi-channel system to play selected frequency point:

***RST**	Reset device
OUTP1 ON	Enables RF output 1
OUTP3 ON	Enables RF output 3
POW1 5	Sets RF output power to 5 dBm
POW3 7	Sets RF output power to 7 dBm
SOUR1:LIST:FREQ 1 GHz,1.5 GHz,2 GHz	Defines list of frequencies
SOUR3:LIST:FREQ 1.2 GHz,1.25 GHz,1.3 GHz	Defines list of frequencies
FCP:MODE 16	Sets FCP to 8-bit Mode
SOUR1:FCP:CONT:LIST ON	Enables FCP on RF output 1
SOUR3:FCP:CONT:LIST ON	Enables FCP on RF output 3
***OPC?**	Check if operation is completed

After successfully configuring RF output 1 and 3, writing 1 to the list word (LW) over the FCP, would simultaneously play

- 1 GHz on RF output 1 with output power of 5 dBm
- 1.2 GHz on RF output 3 with output power of 7 dBm

With FW revision > 0.152, for each RF channel an individual list word can be set.

Electrical Specification

Input signal: 0V to 5 V
Input impedance: 4,7 kΩ
Maximum toggle rate: 10 MHz

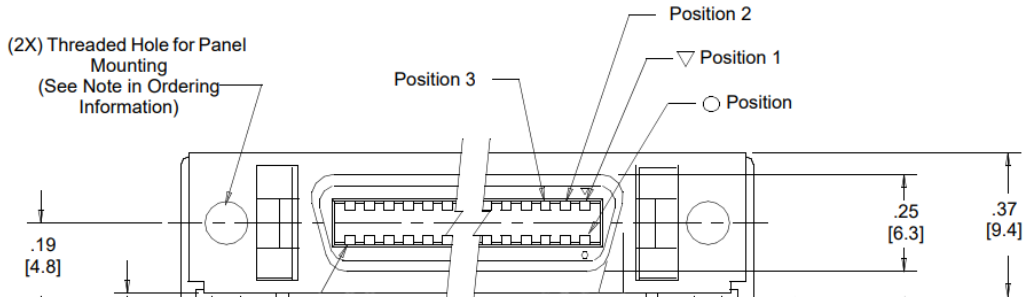

Figure 5 26-pin 3M Mini-D Ribbon connector

Pin	Signal		Pin	Signal	
	8-bit Mode	**16-bit Mode**		**8-bit Mode**	**16-bit Mode**
1	STROBE (in)	STROBE (in)	14	RFU	Data 3
2	Address 0	Address 0	15	RFU	Data 4
3	Address 1	Address 1	16	RFU	Data 5
4	Address 2	Address 2	17	RFU	Data 6
5	Address 3	Address 3	18	RFU	Data 7
6	Data 0	Address 4	19	GND	GND
7	Data 1	Address 5	20	GND	GND
8	Data 2	Address 6	21	GND	GND
9	Data 3	Address 7	22	RFU	RFU
10	ACK (out)	Data 0	23	GND	GND
11	BUSY (out)	BUSY (out)	24	RFU	RFU
12	RFU	Data 1	25	GND	GND
13	RFU	Data 2	26	GND	GND

RFU = Reserved for Future Use. Ports should not be connected

Cable Assembly

For the external wiring of the FCP port a cable with 26 conductors and MDR-connector is available.

To build a custom cable, the individual components are listed below:

Description	Manufacturer Part Number
Connector Plug MDR 26 Pin	3M 10126-3000PE
Connector Backshell MDR 26 Pin	3M 10326-3210-006
Cable shielded 26 wire 28 AWG	3M 3600B/26

The table below lists the mapping of connector pin and wire colors.

Pin	Wire Color		Comments
	Solid	Band	
1	Black	Red	twisted with Pin 20
2	Black	White	
3	White	Black	
4	Blue	Red	
5	Red	Blue	
6	Red	White	
7	White	Red	
8	Red	Brown	
9	Brown	Red	
10	Blue	Black	
11	Black	Blue	
12	Brown	Black	
13	Black	Brown	
14	Orange	Red	
15	Red	Orange	
16	Red	Yellow	
17	Yellow	Red	
18	Black	Yellow	
19	Yellow	Black	
20	Red	Black	twisted with Pin 1
21	Orange	Black	
22	Black	Orange	
23	Green	Black	
24	Black	Green	
25	Green	Red	
26	Red	Green	

Further Documentation

[1] BNC's downloads page:
berkeleynucleonics.com/downloads