DIAMOND
Fiber Optic Components

COUPLERS

Fusion couplers

BASIC INFORMATION

GENERAL

Optical couplers are used for splitting or combining optical signals. They are used in public and private optical fiber networks to serve as passive distribution and collection points for optical data transmission (telephone, cable TV etc.). Other applications for optical couplers are measuring equipment, measuring instruments and sensor technology.

FEATURES

- Low insertion loss
- High return loss
- Wavelength-selective or broadband properties
- High thermal and mechanical stability
- For any coupling ratio (1 % ... 50 %)
- Manufactured to customer specifications

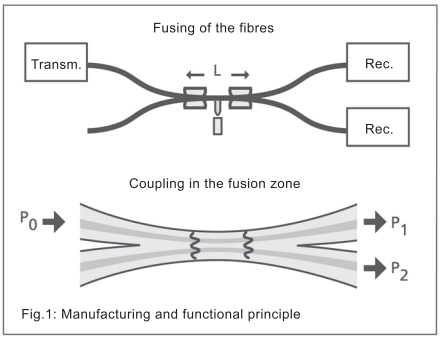

Fig.1: Manufacturing and functional principle

MANUFACTURING PROCEDURES

Fusion couplers are manufactured by the so-called FBT method (fused biconical taper), in which coupling zones are created by fusion and simultaneous pulling and narrowing (tapering) of optical fibers (fig. 1). The basic material is a single mode fiber with a protective plastic coating (primary coating, Ø 250 µm). To produce a coupler with two outlets, first a short section of the primary coating is removed in the middle of two optical fibers. The stripped sections are carefully cleaned, aligned parallel to each other and fixed in place. The subsequent process of fusing and simultaneous tapering allows the light to pass, or be coupled, from one core into the other. Thus, the two fibers form a pure glass connection which is not interrupted by a joint, as it would be with an adhesive joint or filter. The fusing and tapering process is controlled by a complicated measuring device which permits simultaneous measurement, enabling the traction process to be interrupted at any point, and thus enabling the degree of coupling of the input signal into the second fiber, or the coupling ratio, to be controlled (fig. 2).

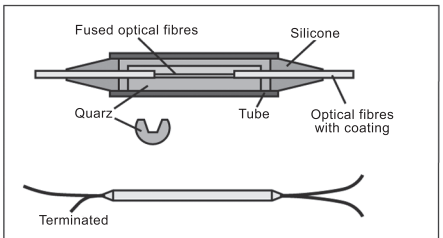

Fig. 2: Schematic structure of a fusion coupler

After the tapering process the coupler is bonded to a quartz substrate with a special adhesive. The substrate and coupler are inserted into a metall tube and the ends of the tube are closed with silicone.
After encapsulation, the coupler has two input fibers and two output fibers (=2x2 coupler). A non-reflecting termination on one input fiber will create a 1x2 configuration (fig. 3).

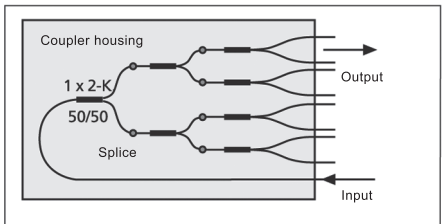

Fig. 3: Basic structure of a 1x8 coupler module

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TECHNOLOGY BASICS

By manipulating the tapering process and by special pre-treatment of the optical fibers to be fused, couplers with various transmission and coupling properties can be made.

As seen in fig. 4, the coupling ratio depends both on the tapering length and on the working wavelength. To achieve a specific coupling ratio at one wavelength, the taperinglength must be precisely controlled.

Point **A** marks a standard coupler (SSC = Standard Singlemode Coupler) with a coupling ratio of 50 % at 1550 nm. If this coupler is operated with a wavelength of 1310 nm, the coupling ratio is approx. 20 %.

Point **B** marks a standard coupler (SSC) with a symmetrical coupling ratio at 1310 nm. The coupling ratio of standard couplers is inherently sensitive to changes in wavelengths (Fig.5).

Point **C** marks a single window coupler (WFC = Wavelength Flatened Coupler) for 1550 nm.
Wavelength Flattened Couplers maintain a rather stable coupling ration within a narrow wavelength window (~ +/- 40nm), but exhibit more significant variations outside this narrow wavelength band (Fig.6).

Point **D** marks a dual window coupler (WIC = Wavelength Independent Coupler). At this intersection, the coupling ratio is the same for two wavelengths (fig 7).
By altering the tapering process further, couplers with more specific characteristics may be achieved, such as: dual window couplers with expanded wavelength range (EIC = Expanded Wavelength Independent Coupler), three window couplers (FIC = Full range Wavelength Independent Coupler) or couplers with specific wavelength specifications (see „types of couplers“ section).

Point **E** marks a wavelength multiplexer (WDM = Wavelength Division Multiplexer). At this point, 100 % of the signal at 1550 nm and 0 % of the signal at 1310 nm is coupled. Figure 8 shows the reverse effect.
This means that a WDM, like a filter, can separate two wavelengths so that each output carries only one wavelength.
Since light can be coupled bi-directionally, two wavelengths can be combined over the same fiber link simultaneously.

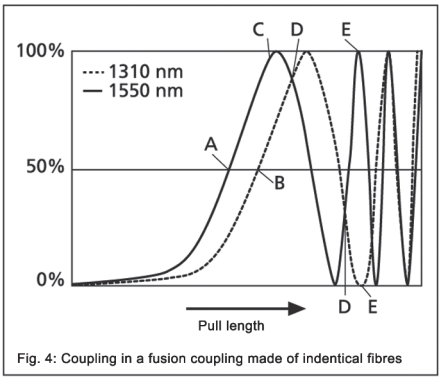


Fig. 4: Coupling in a fusion coupling made of indentical fibres

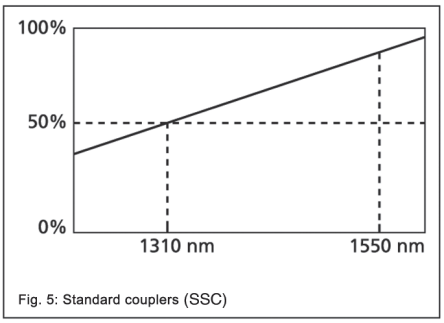


Fig. 5: Standard couplers (SSC)

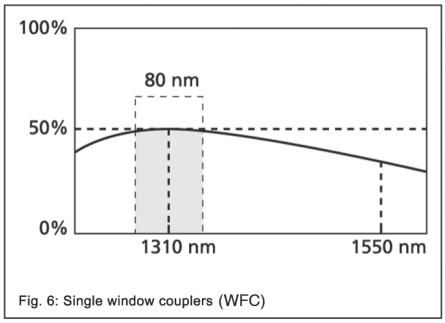


Fig. 6: Single window couplers (WFC)

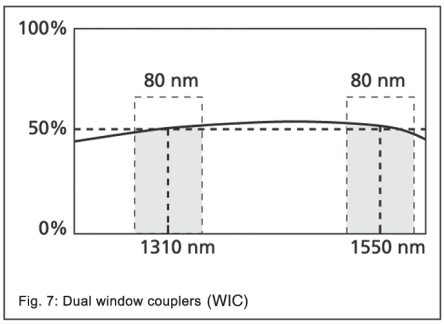


Fig. 7: Dual window couplers (WIC)

QUALITY ASSURANCE

Every coupler can be identified by a serial number, i.e. it is possible at any time to identify the manufacturing parameters, the workplace and the material used for any coupler. Each component is subjected to a burn-in test and a temperature test to ensure long-term stability.
At the same time, long-term tests based on Telcordia TR-NWT-001209 and TA-NWT-001221, such as storage in moist and dry heat, temperature cycles and mechanical strain were successfully passed.

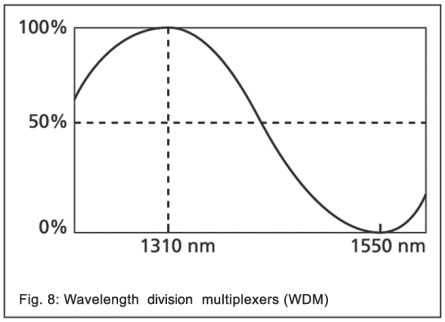
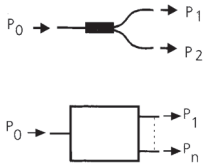
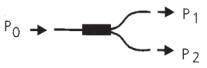
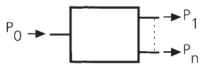
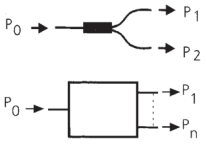
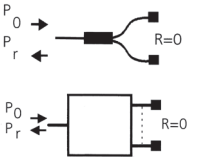
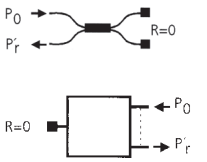
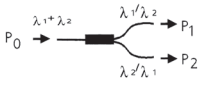


Fig. 8: Wavelength division multiplexers (WDM)

Definitions of the characteristics for couplers (C), coupler modules (CM) and wavelength division multiplexers (WDM)

TERM	DEFINITION	COMPONENT	CALCULATION	UNIT	EXPLANATION
Insertion Loss	Sum of coupling loss and excess loss	C WDM CM	$-10 \log (P_{1/2} / P_0)$ $-10 \log (P_i / P_0)$ (i= 1....n)	[dB] [dB]	
Coupling Ratio	Percentage division ratio of the optical signals to the outputs points	C	$[(P_2/(P_1+P_2)] \times 100$ $-10 \log [P_{1/2} / (P_1+P_2)]$	[%] [dB]	
Splitting Ratio	Percentage division ratio of the optical signals to the outputs points	CM	$[P_i / \Sigma P_n] \times 100$ $-10 \log [P_i / \Sigma P_n]$	[%] [dB]	
Excess Loss	Propotion of the signal that is present at the input but none of the outputs points	C CM	$-10 \log [(P_1 + P_2) / P_0]$ $-10 \log [\Sigma P_n / P_0]$	[dB] [dB]	
Return Loss	Ratio of transmitted signal to reflected signal at one input or output	C WDM CM	$-10 \log (P_r / P_0)$ $-10 \log (P_r / P_0)$	[dB] [dB]	
Directivity	Proportion of transmitted signal which is reflected to the parallel fiber on the same side	C WDM CM	$-10 \log (P'_r / P_0)$ $-10 \log (P'_r / P_0)$	[dB] [dB]	
Isolation	Power ratio of the undesirable wavelength to the desirable wavelength. The isolation is dependent on the working wavelength range.	WDM	$-10 \log [P_{1/\lambda 1} / P_{2/\lambda 1}]$ $-10 \log [P_{2/\lambda 2} / P_{1/\lambda 2}]$	[dB] [dB]	

AVAILABLE COUPLER TYPES

STANDARD-SINGLE MODE COUPLER/COUPLER MODULES

COUPLER TYPE		SSC	WFC	WIC	EIC	FIC
Wavelengths	[nm]	1310, 1550, 1625		1310 & 1550		
Bandwidth	[nm]	±5	±40	±40	-	-
Bandwidth at 1310 nm at 1550 nm	 [nm] [nm]	 - -		 - -	 ±50 +50/-100	 ±50 ±100
Configuration: Single coupler Coupler Module		1x2, 2x2, 1x3, 1x4 1x2, 1x4, 1x6, 1x8, 1x12, 1x16, 1x24, 1x32 2x2, 2x4, 2x6, 2x8, 2x12, 2x16, 2x24, 2x32				
Housing type		EK: BG 01, 02, 03, 04, 05, 06 M: BG10, 19"/1HE, 3HE/7TE, ETSI Table housing				

SPECIAL SINGLE MODE COUPLERS

COUPLER TYPE		SBC	CBC	CLC	SCL
Lower Wavelengths	[nm]	1460	1530	1530	1460
Higher Wavelengths	[nm]	1530	1565	1625	1625
Configuration		1x2, 2x2, 1x3, 1x4			
Housing type		EK: BG 01, 02, 03, 04, 05, 06 M: BG10, 19"/1HE, 3HE/7TE, ETSI Table housing			

SINGLE MODE SHORT WAVELENGTH COUPLERS (SWC)

Wavelengths	[nm]	488, 533, 650, 760, 850
Configuration		1x2, 2x2, 1x3, 2x3, 3x3 1x4, 2x4, 3x4, 4x4
Housing type		EK: BG 01, 02, 03, 04, 05, 06 M: BG10, 19"/1HE, 3HE/7TE, ETSI, Table housing

WAVELENGTH DIVISION MULTIPLEXERS (WDM), WDM MODULES

WDM TYPE		NARROWBAND-WDM		WIDEBAND-WDM	
Wavelengths	[nm]	1310 / 1550	1310 / 1625	1310 / 1550	1310 / 1625
Bandwidth	[nm]	±20 / ±20	±20 / ±20	±40 / ±40	±40 / ±40
Housing type: Single-WDM WDM Module		BG02, BG03, BG04, BG05, BG06 ab BG10			

MULTIMODE COUPLERS/COUPLER MODULES

Wavelengths	[nm]	820	1300	820-1300
Bandwidth	[nm]	±40	±40	-
Wavelength Range Min. Max.	 [nm] [nm]	 - -	 - -	 780 1340
Configuration (Single coupler)		1x2, 2x2		
Configuration (Coupler Module) Tree-Coupler modules Star-Coupler modules		1x2, 2x2, 1x4, 2x4, 1x6, 1x8, 2x8, 1x12, 1x16, 2x16, 1x32, 2x32 4x4, 8x8, 16x16, 32x32		
Housing type		EK: BG04, 02, 03, 05, 06 M: BG10, 19"/1HE, 3HE/7TE, ETSI, Table housing		

SINGLE MODE ATTENUATORS

COUPLER TYPE		ASW		ADW	ATW	
Wavelengths	[nm]	1310, 1550, 1625		1310 & 1550		
Bandwidth	[nm]	-	±40	±40	-	-
Bandwidth at 1310 nm at 1550 nm Attenuation	 [nm] [nm] [dB]	 - - 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25		 - -	 ±50 +50/-100	 ±50 ±100

Other coupler types upon request.

NOTE Please contact your local Diamond representative for additional information