

Description

The invention relates to an optical component for two or more optical fibres according to the preamble of Claim 1. Such an optical component is used in fibre-optical transmission systems.

An optical component of the generic type is previously known from EP 0.075.704 A3. Herein, a liquid is provided as adjusting member in the slot-type guide space between the two supports for the fibres. For each fibre, a respective pair of electrodes is applied to the guide space faces of the supports, said pair of electrodes each being formed by an upper electrode and a lower electrode separated therefrom. In the slot-type guide space there is fitted a respective pair of liquid drops per pair of fibres arranged flush with each other, said pair of liquid drops being composed of two liquids having different dielectrics, one being transparent and the other being opaque. For vertically displacing each pair of drops, a voltage is applied between the upper electrode or the lower electrode on the one support and the associated electrode on the other support of the assigned pair of electrodes. When the voltage is applied between the upper electrode and the lower electrode, the pair of liquid drops is displaced vertically in one direction. When, however, the voltage is applied between the lower electrode and the upper electrode, the pair of liquid drops is displaced vertically in the opposite direction. In this way, as desired the transparent or the opaque drop can be brought between the assigned fibres arranged flush with each other. It is essential that an electrical field is generated at all in the slot-type guide space. This optical component can, however, only serve as an on/off switch or as a change-over switch for two glass fibres.

Furthermore, optical components such as attenuation element, filter, power divider or the like are previously known. There is, for example, an optical attenuation element consisting of a box-type housing, in the opposite side walls of which supports

in the form of couplings for the optical fibres are constructed. Thereto, optical imaging systems in the form of spherical lenses are assigned on the inner sides of the housing for light beam expansion. Within the interior, a circular disc is borne by axle journals in the side walls of the housing, the optical axes of the fibres being arranged spaced from the axis of rotation of the disc. The disc carries, as a filter magazine, various filter discs, to each of which a respective latch position is assigned. By turning the filter disc, it can be turned into different latch positions, such that different attenuation values may be set.

It is disadvantageous, here, that adjustment of the different filters in each case has to be done manually, directly at the optical attenuation element.

It is the object of the invention, therefore, to provide an optical component of the generic type, which can be constructed with remote actuation of the adjusting element as an attenuation element, filter, power divider or the like.

The solution for this object results from the characterizing features of Claim 1. The optical component according to the invention provides on the basis of a defined input signal via the control system a local displacement of the electrical field between the guide plates, which are at the same time supports or carriers of the optical fibres and where appropriate are provided with optical imaging systems. By means of the electrical field, the adjustment plate having different optical properties is positioned in predetermined, discrete positions, such that different attenuation values, filter curves, power divisions or the like are possible. The optical component according to the invention can, thus, be constructed as remote-actuable attenuation element or as remote-actuable filter, power divider or the like.

Further advantageous embodiments of the invention result from the sub-claims.

In the following, the invention is described in more detail with reference to several embodiments of optical components, represented in the drawings. In these:

Fig. 1 shows the physical principle of the optical component,

Fig. 2 shows the first embodiment of the optical component in a vertical section,

Fig. 3 shows the optical component according to Fig. 2 in a turned vertical section,

Fig. 4 shows a horizontal section through the second embodiment of the optical component,

Fig. 5 shows a horizontal section through the third embodiment of the optical component,

Fig. 6 shows a horizontal section through the fourth embodiment of the optical component,

Fig. 7 shows a horizontal section through the fifth embodiment of the optical component,

Fig. 8 shows a vertical section through the optical component in the fifth embodiment,

Fig. 9 shows a principle representation of an optical imaging system,

Fig. 10 shows a principle representation of the sixth embodiment of the optical component as an electrically adjustable optical power divider,

Fig. 11 shows the seventh embodiment of the optical component as an electrically adjustable optical power divider,

Fig. 12 shows a horizontal section through the eighth embodiment of the optical component as an electrically adjustable optical filter,

Fig. 13 shows the curve in principle of the transmitted power of the optical filter according to Fig. 12 as a function of the wavelength and of the adjustment of the adjustment plate, and

Fig. 14 shows the ninth embodiment of the optical component as an electrically controllable optical change-over switch.

The physical basis of the optical component according to the invention is the fact that a movable dielectric 1 in the field of a plate capacitor 2 is attracted into the latter, if first, according to Fig. 1, the dielectric 1 is partially outside the action of the field (transition partially into the state of minimum energy). The force F acting on the dielectric 1 is, with constant charge Q on the capacitor plates 2

$$F_Q = \frac{1}{2} \cdot \frac{\epsilon - \epsilon_0}{[\epsilon_0 a + (\epsilon - \epsilon_0) x]^2} \cdot \frac{d}{h} \cdot Q^2$$

where $x < a$,

and ϵ_0 is the dielectric constant of the ambient space, ϵ the dielectric constant of the dielectric 1, and h the dimension of the system perpendicular to the drawing plane. The remaining values are introduced as in Fig. 1.

For a constant voltage U , this force is

$$F_U = \frac{1}{2} \cdot (\epsilon - \epsilon_0) \cdot \frac{U^2}{d} \cdot \frac{h}{a}$$

where $x < a$.

The optical component according to the invention is based on this fundamental physical principle, and in accordance with this optical component the dielectric 1 can accurately be positioned by means of an electrical field in discrete positions between the capacitor plates 2.

Figs. 2 and 3 show the first embodiment of the optical component, which consists of two parallel guide plates 10, 11 at a distance d and of an adjustment plate 12 movable therebetween. Inserted into the guide plates 10, 11 are the optical fibres 13, 14 with their optical imaging systems 19 such that their free end faces are arranged opposed to the movable adjustment plate 12. The guide plates 10, 11 and the adjustment plate 12 consist of dielectric material, e.g. glass panes. On the inner sides of the respective guide plates 10, 11 are disposed parallel rows of conductive electrode strips 15, 16. They may consist of transparent material applied by vapour deposition. The individual electrode strips 15, 16 of each guide plate 10, 11 are provided with terminals 18 connected to a control system not shown in detail, said control system effecting the voltage change-over between the individual electrode strips 15, 16.

The complete optical component consisting of the guide plates 10, 11 and of the adjustment plate 12 is arranged within a hermetically sealed housing filled with a liquid having an appropriate index.

On application of the voltage to the electrodes 15, 16 or their terminals 18, identified by the letters B_1 to B_j , and on disconnection of the voltage at the electrodes 15, 16 or their terminals 18, identified by the letters A_1 to A_k , the electrical field moves. Because of the fundamental physical principle described at the outset, the dielectric adjustment plate 12 keeps moving to new positions and can, depending on the number, distance and size of the electrodes 15, 16, occupy a plurality of discrete positions. Here, friction is kept extremely low by adding the liquid of an appropriate index.

The voltage can be applied to the electrode strips 15, 16 of both guide plates 10, 11 such that the necessary change-overs are effected by semiconductor components produced by the chip-on-glass technique on one of the guide plates 10, 11. This is a conventional technique for LCD chips. Then, only the voltages for building-up the electrical field at one point and the necessary control signals have to be supplied to the semiconductor components.

Power consumption is extremely low, as the work required to move the adjustment plate 12 to a new position is only low. Only partial capacitances have to be charged. The periods of time for refixing the adjustment plate 12, said periods of time being determined by these partial capacitances and by the inertia of the adjustment plate 12, are in the order of milliseconds.

In a technical embodiment, because of the desired movement in only one straight-line coordinate, the adjustment plate 12 must be fixed either by the field itself or by a groove or by spacer pieces. As, advantageously, the fixed state should be maintained even in the case of disconnected voltage, mechanical fixing is advantageous.

The starting position has to be effected by inertialisation electrically or by mechanical means, e.g. by a travelling electrical field over the complete range of movement, and then by a controlled movement into a defined starting position.

In the second embodiment according to Fig. 4, there is represented an optical component consisting of two guide plates 20, 21 and an adjustment plate 22 guided in a guide space 27 made in the guide plate 21. The electrode strips 25, 26 are arranged on the surfaces of both guide plates 20, 21 in each case in the area of the adjustment plate 22. Optical imaging systems 29 are assigned to the fibres 23, 24.

In Fig. 5, the third embodiment is shown, this embodiment

being particularly advantageous for simple manufacture. Here, optical imaging systems 39 are assigned to the fibres 33, 34 in each case. Only one dielectric guide plate 31, in which the guide space 37 for the adjustment plate 32 has been made as a recess, is equipped with two rows of electrode strips 35, 36 applied by vapour deposition and arranged on either side of the guide space 37 for the adjustment plate 32. In the same way, the guide plate 31 could, instead of the electrode strips 35, 36, be provided with semiconductor components by the chip-on-glass technique. The voltage necessary for achieving the same power effect as in the two first embodiments is, however, larger.

The fourth embodiment, shown in Fig. 6, consists of a plane guide plate 40, the second guide plate 41, which is provided with the guide space 47 for the adjustment plate 42 and into which the optical fibres 43, 44 are inserted by means of optical imaging systems 49, and two rows of electrode strips 45, 46 constructed on both edge regions of the guide space 47 of the guide plate 41. This embodiment can be used, for instance, as an electrically adjustable optical attenuation element.

In the fifth embodiment of an optical component, shown in Figs. 7 and 8, the guide groove 57 for the adjustment plate 52 is, in contrast to the fourth embodiment, constructed in the same way in both guide plates 50, 51. The electrode strips 55, 56 are in each case disposed on the outer sides of the guide plates 50, 51 in the area of the guide space 57 and of the adjustment plate 56 guided movably therein. The fibres 53, 54 terminate in optical imaging systems 59 inserted into the guide plates 50, 51.

Fig. 9 shows an optical imaging system 59 between a fibre 53 as a collimated bundle and the fibre end of the other fibre 54.

In the following, special optical components are described in more detail which are based on the fundamental physical principle explained at the outset and apply the embodiments of

Figs. 2 to 7 for fixing the adjustment plate or for building up the electrical field; they are to be understood as examples only, as, in principle, all embodiments are always possible.

On optical transmission paths, path attenuation must be adjusted to a set value and be held constant over long periods of time. Depending on the receiving level, a telemetry signal can be transmitted to the transmitter, and an optical attenuation member can be adjusted by a control signal such that the deviation of the attenuation from the set value remains below a predetermined threshold. To achieve these functions there serves, for instance, the fifth embodiment according to Figs. 7 and 8 as an electrically adjustable optical attenuation member. Here, the adjustment plate 52, i.e. a dielectric disc with transmission variable along the longitudinal direction, is moved between the end faces of the optical fibres 53, 54 on the basis of the fundamental physical principle described at the outset. Depending on the position of the adjustment plate 52, the attenuation can be established in steps between a maximum value and a minimum value, and depends on the number of electrode strips 55, 56 and on the continuous variation of the transmission of the adjustment plate 52. Herein, the guide space 57 has a depth corresponding to the width of the adjustment plate 52.

Figs. 10 and 11 show as principle representations the sixth and seventh embodiments of the optical component as an optical power divider with electrically adjustable division ratio. In communication networks with optical transmission, diverting a defined portion of the optical power from the transmission path is an important function.

In the optical components of an electrically controllable power divider, shown in principle Figs. 10 and 11, an adjustment plate 62 or 72 respectively, consisting of interference filters which are different in sections, is brought, in accordance with the embodiments of an optical component described above, into the optical path between input fibre 60, 70 and two output fibres 61,

61' or 71, 71' respectively. By means of electrical control signals, the guide plate 62, 72 is brought in steps of discrete size into selected positions between the guide plates (not shown) carrying the electrode strips, also not shown. Here, filters of variable transmission or reflection, formed by the adjustment plates 62 or 72, become effective in the optical beam path. The reflected optical power portion is diverted via a semi-transparent mirror 68 into an output fibre 61' (Fig. 10).

Fig. 12 shows the eighth embodiment of an optical component as an electrically adjustable optical filter. In wavelength multiplex transmission systems, a filter must be used at the end of the path for selection of the signal of a particular wavelength. With a variable filter, signals having different wavelengths can easily be separated. Here, the adjustment plate 82 forms the filter, the position of which is electrically controllable. The filter is movable between the guide plates 80, 81 according to the above-described principle, between the end sides of the input fibre 83 and the output fibre 84.

Fig. 13 shows the curve in principle of the diverted optical power for different wavelengths λ and movement of the adjustment plate 82 in the direction of arrow A (curve A) or in the direction of arrow B (curve B).

Finally, in Fig. 14, an electrically controllable optical change-over switch is shown as a ninth embodiment of the optical component. In networks with optical transmission, it is helpful to activate replacement paths in the event of a failure of individual components or network branches, e.g. in local networks with a ring-type structure. For this, optical change-over switches are necessary for coupling the signal of a fibre, the input fibre 93, into one of two possible output fibres 94, 94'. Known switches make use, for this, of a direct mechanical or piezo-electrically controlled movement of the fibre. With the arrangement of the adjustment plate 92 between two guide plates 90, 91 each consisting of dielectric material, a simple

change-over can be achieved by means of the transparent dielectric adjustment plate 92 if its refractive index n_2 is suitably selected with respect to the refractive index n_1 of the other materials. This means that optical coupling matrices can also be built up to be used in optical exchange networks.

Optical switches can also be produced with an arrangement identical to the fifth embodiment of the optical component shown in Figs. 7 and 8, if the adjustment plate 52 is replaced by a non-transparent adjustment plate moved in a liquid of an appropriate index. Such switches can, even with very large diameters of the fibre core, be used as optical switches in display systems with fibre-optical light guidance and there replace other, less effective switches. It is advantageous, here, to construct switch arrays of which the dimensions are oriented towards the sizes of characters or images.

Claims

1. Optical component for two or more optical fibres (13, 14; 23, 24; ...) consisting of at least two supports (10, 11; 20, 21; ...) for the fibres, a guide space (27, 37, ...) formed between the supports for an adjustment member (12, 22, ...) movable therein, and electrode surfaces disposed in the guide space and connectable to a regulable power source for generating an electrical field for moving the adjustment member in the guide space, characterized in that the adjustment member (12, 22, ...) is constructed from a plate of dielectric material; in that the supports (10, 11; 20, 21; ...) are constructed as plates between which the adjustment member (12, 22, ...) is guided; and in that the electrode surfaces are formed from a plurality of spaced electrode strips (15, 16; 25, 26; ...) provided with terminals (18) and connected to a control system, the control system making possible a voltage change-over between the individual electrode strips (15, 16; 25, 26; ...) in order thus to generate a moving electrical field between the support plates (10, 11; 20, 21; ...) for linearly displacing the adjustment plate (12, 22;) into a plurality of discrete positions.

2. Optical component according to Claim 1, characterized in that the dielectric material is glass.

3. Optical component according to Claim 1, characterized in that the electrode strips (15, 16; 25, 26; ...) are made of conductive, transparent material.

4. Optical component according to one of Claims 1 or 3, characterized in that the electrode strips (15, 16; 25, 26; ...) are applied by vapour deposition to the interior surfaces of the support plates (10, 11; 20, 21; ...).

5. Optical component according to one of Claims 1 to 4, characterized in that the guide space (17; 27; ...) for the adjustment plate (12; 22; ...) is formed in a recess of one



support plate (11; 21; ...).

6. Optical component according to one of Claims 1 to 5, characterized in that the electrode strips (15, 16; 25, 26; ...) are constructed as two parallel rows on the faces facing the guide space (17; 27; ...), of the support plates (10, 11; 20, 21; ...).

7. Optical component according to one of Claims 1 to 5, characterized in that the electrode strips (15, 16; 25, 26; ...) are constructed as two parallel rows on the lateral surfaces of the guide space (37; 47) of one support plate (31; 41).

8. Optical component according to one of Claims 1 to 7, characterized in that the thickness of the guide plate (12; 22; ...) forms the depth of the support space (17; 27; ...).

9. Optical component according to one of Claims 1 to 7, characterized in that the width of the support plate (42) forms the depth of the guide space (47).

10. Optical component according to one of Claims 1 to 9, characterized in that the guide space (57) is constructed from two recesses in the surfaces of both support plates (50, 51), and in that the electrode strips (55, 56) are constructed on the outer walls of the support plates (50, 51) in the area of the adjustment plate (52).