



Tipologia documento:
Specifica tecnica

Fornitura di una Sonda Ottica per il Monitoraggio delle Dinamiche di Combustione

Specifica tecnica

Preparata: Dott. Stefano Chiocchini

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1. PREMESSA

Il presente documento descrive le attività che Co.Svi.G. S.c.r.l. richiede di svolgere al "Fornitore", relativamente alla realizzazione di una "Sonda Ottica per il Monitoraggio delle Dinamiche di Combustione" (nel seguito semplicemente "Sonda Ottica", o "Sonda", o "Manufatto"). La "Sonda Ottica" oggetto della fornitura, sarà installata nel locale cella di prova combustori, sito presso l'impianto sperimentale Sesta LAB (www.sestalab.com, S.P. 35 Km 2,7 - 53030 Radicondoli, SI, ITALY. GPS N 43°-13'-45.552" , E 10°-56'-51.468"), di proprietà Co.Svi.G. S.c.r.l.. Più precisamente la "Sonda Ottica" verrà integrata nel bruciatore di proprietà del "cliente" (committente delle campagne sperimentali presso Sesta LAB), entrando a far parte del complesso strumentale-diagnostico che equipaggia il combustore in prova (almeno per la prima fase di collaudo e validazione funzionale del "Complesso Assemblato¹" bruciatore-sonda).

Funzionalmente la "Sonda Ottica" costituirà il primo elemento (sensore) di una catena di misura opto-meccanica ed opto-elettronica, finalizzata alla diagnosi in tempo reale delle instabilità di combustione termo-acustiche in bruciatori per turbogas.

In una prima serie di test preliminari, per validare l'effettiva capacità diagnostica della suddetta catena di misura, i segnali campionati dalla sonda verranno analizzati "in differita" (off-line), oppure in tempo reale (on-line), comparando i risultati dell'analisi con quelli parallelamente forniti dal sistema diagnostico del "cliente".

Accertata detta capacità, assieme con il "cliente" verrà valutato se procedere all'integrazione della "Sonda" e della relativa catena di misura in un sistema per il controllo attivo della macchina (turbogas). In altre parole, un indice di incipiente instabilità, valutato istante per istante sui

¹ Lancia dell'olio o bruciatore aero-derivato (vedere § 2, DESCRIZIONE DELLA FORNITURA), completamente equipaggiato con gli elementi funzionali opto-elettronici ed opto-meccanici della "Sonda".

segnali campionati dalla sonda, verrà impiegato come soglia di attivazione per un attuatore. Quest'ultimo provvederà quindi a regolare i parametri operativi della macchina, mantenendola al di fuori della regione di funzionamento instabile.

Visto che la fornitura verrà inquadrata all'interno del "BANDO FAR-FAS 2014" della Regione Toscana e nel "Piano Nazionale Industria 4.0" promosso dal Ministero dello Sviluppo Economico, il "Fornitore" dovrà produrre attestazioni/dichiarazioni che certifichino le caratteristiche e la tipologia del materiale acquistato come conformi agli utilizzi dettagliati nella presente Specifica Tecnica.

2. DESCRIZIONE DELLA FORNITURA

La fornitura in oggetto prevede la realizzazione di una "Sonda Ottica per il Monitoraggio delle Dinamiche di Combustione", come descritta nel seguito.

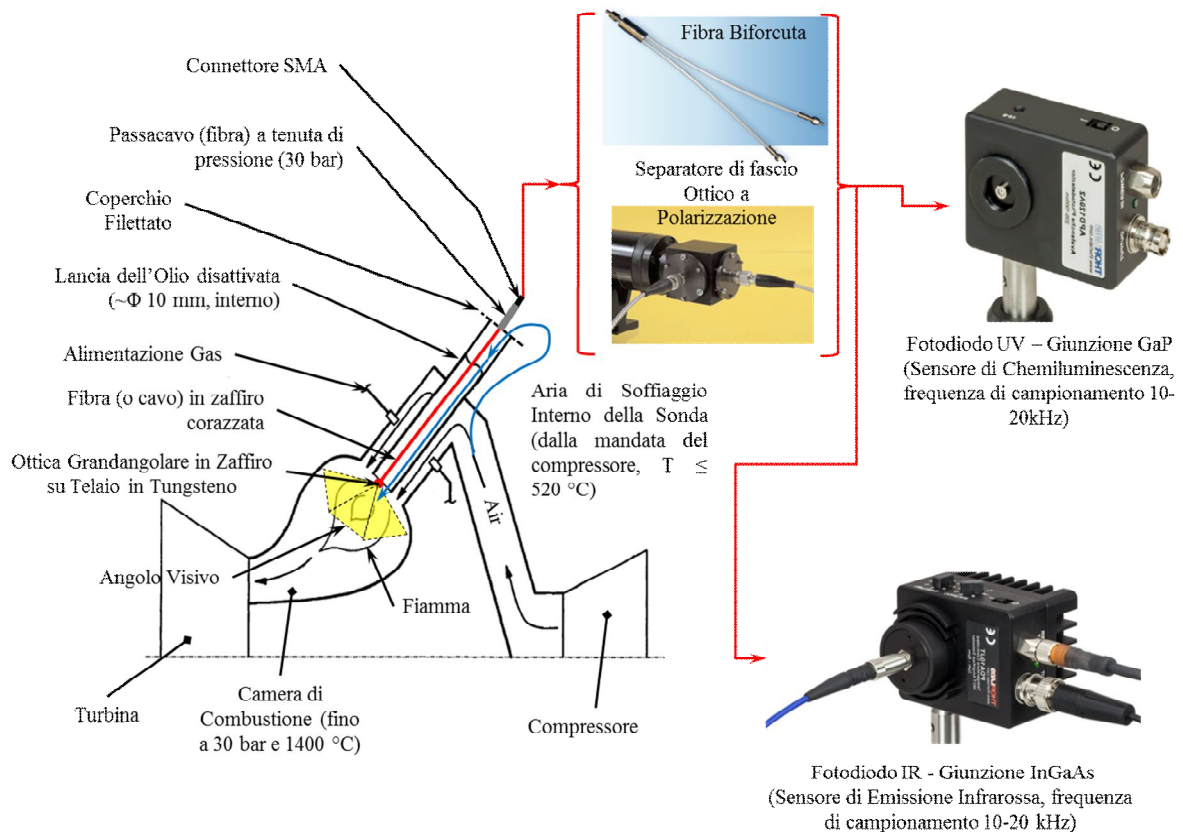


Figura 1



In una prima forma realizzativa, nel seguito "Esecuzione 1" (Figura 1), partendo dal lato in cui la "Sonda" si affaccia all'interno della camera di combustione, la catena di misura ottica dovrà comporsi di:

1. Una micro-ottica grandangolare in zaffiro, del diametro di circa 10 mm [per una misura più precisa vedere Allegato A)], ed angolo visivo di 97 gradi. Le lenti dell'ottica dovranno subire trattamento Anti Riflesso (AR) efficace nell'intero campo di lunghezze d'onda 250-4500 nm e resistente alla temperatura di esercizio prevista (520 °C), con picchi occasionali di 1400 °C, ciascuno della durata di 1 min., durante i fenomeni di "flame-flashback". È preferibile che la corretta focalizzazione del fascio ottico captato dalla "Sonda" internamente alla sezione terminale della fibra ottica trasmittitrice (designata come "Fibra corazzata in zaffiro" in Figura 1), sia verificata tramite simulazioni numeriche. La massima percentuale ammessa di "raggi dispersi" sarà del 5-7%, per incidenza al limite del campo visivo. L'esecuzione di detta verifica, opzionale, darà diritto ad una quota parte del punteggio assegnato all'offerta del "Fornitore", secondo quanto descritto nel "Disciplinare di Gara".
2. Un telaio per l'alloggiamento della micro-ottica, realizzato in materiale metallico ed innestato sull'estremità anteriore della lancia dell'olio. Il materiale per la realizzazione del telaio sarà presumibilmente tungsteno, od altro atto ad assicurare, sino alla massima temperatura di esercizio (520°C con picchi occasionali fino a 1400°C, della durata di 1 min.), la resistenza in sicurezza alle sollecitazioni termomeccaniche e la congruenza tra le dilatazioni termiche proprie e delle lenti incastonate. L'ingombro radiale del telaio dovrà consentire l'esecuzione, all'estremità della lancia dell'olio, di una corona di fori, od altra apertura, per lo sfogo dell'aria di soffiaggio interna della sonda, ad evitare il deposito di fuliggine sull'ottica.



3. Un'interfaccia tra la micro-ottica e la fibra ottica, od il cavo multifibra, in zaffiro, che raccoglie il fascio focalizzato dalla prima. In special modo nel caso di impiego di una singola fibra si dovranno prendere adeguati provvedimenti affinché l'estremità della fibra stessa risulti solidale con l'ottica ed il relativo telaio, impedendo che le vibrazioni dell'assieme e le oscillazioni indotte nella fibra dall'aria di soffiaggio causino occasionali focalizzazioni al di fuori della sezione terminale della fibra. Sarà cura del "Fornitore" motivare tecnicamente la soluzione preferita: singola fibra o cavo, ed in quest'ultimo caso il numero di fibre prescelto. Co.Svi.G. S.c.r.l. (Sesta LAB) si riserverà di accettare la soluzione proposta, a suo insindacabile giudizio.
4. Una fibra, od un cavo multi-fibra, in zaffiro, con l'estremità anteriore giacente nel piano di focalizzazione della micro-ottica, e con sezione sufficiente a racchiudere l'intera area di focalizzazione (anche in presenza di vibrazioni che causino un parziale disallineamento tra fibra ed ottica). La fibra od il cavo, dovrà essere munito di un'apposita corazza in acciaio flessibile, adatta per l'esercizio continuativo alla temperatura ed alla pressione di progetto ($T \leq 520^\circ\text{C}$, $p \leq 30$ bar). Tra la fibra, od il cavo, e la corazza di acciaio dovrà essere interposta una guaina protettiva flessibile in fibra di vetro. La caratteristica di attenuazione "da catalogo" della fibra, al variare della lunghezza d'onda tra 250 e 4500 nm⁽²⁾, dovrà essere trasmessa per approvazione, ad insindacabile giudizio di Co.Svi.G.
5. Un passacavo (fibra) a tenuta di pressione (30 bar) e compatibile con la temperatura di esercizio, che dovrà essere assunta paria alla temperatura dell'aria di spurgo della sonda (520 °C). Il passacavo dovrà terminare esternamente con un connettore SMA 905. La lancia dell'olio [allegato A)] verrà messa a disposizione dal "cliente" e resa accessibile al fornitore per le necessarie lavorazioni di assemblaggio



dell'ottica, telaio, interfaccia ottica-fibra, fibra e passacavo. È preferibile che il comportamento termo-strutturale del "Complesso Assemblato" (assieme dei componenti sin qui elencati, integrati nella lancia dell'olio) sia verificato tramite apposite simulazioni numeriche, contemplando le problematiche di dilatazione termica differenziale tra il telaio metallico dell'ottica e le lenti. L'esecuzione di detta verifica, opzionale, darà diritto ad una quota parte del punteggio assegnato all'offerta del "Fornitore", secondo quanto descritto nel "Disciplinare di Gara".

6. Una "Fibra Biforcata" (fiber splitter) oppure un "Separatore di Fascio Ottico a Polarizzazione" (beam splitter), per la suddivisione del fascio trasmesso dalla fibra interna alla lancia dell'olio in due rami. In ogni caso sarà da valutare l'adozione di un breve tratto di fibra esterna intermedia ancora in zaffiro, per preservare il fiber splitter od il beam splitter da eccessive temperature. Il ramo che va verso il fotodiodo UV dovrà essere realizzato in fibra per ultravioletto profondo, anti-solarizzazione (DUV-NS, Deep UV Non-Solarising), possibilmente con attenuazione minima nel range di lunghezze d'onda 250-500 nm. La caratteristica di attenuazione "da catalogo" della singola fibra nel suddetto campo, e la curva di decadimento della trasmittanza col tempo di esposizione alla radiazione UV (per almeno 1000 ore), dovranno essere trasmesse preliminarmente per approvazione ad insindacabile giudizio di Co.Svi.G.. Il ramo che porta verso il sensore IR dovrà essere realizzato in fibre per MIR (Medio Infrarosso), in ZrF₄, con attenuazione minima nel campo 1500-3500 nm.

Nel caso in cui la guida d'onda interna sia realizzata nella forma di un bundle, questo potrà essere concepito come una fibra biforcata, che fuoriesca dalla lancia dell'olio, per poi biforcarsi in due rami. Sarà così evitato il ricorso al fiber splitter esterno.

² Anche se i sensori InGaAs non arrivano al limite superiore dichiarato per le lunghezze d'onda è in programma di sostituirli in un prossimo futuro, con altri in grado di raggiungere detto limite.

Come requisito opzionale è richiesto al "Fornitore" di generare (eventualmente avvalendosi di uno studio di progettazione esterno), tenuto conto dei materiali ottici impiegati, le caratteristiche di risposta spettrale "attese" dell'intera catena di misura: dall'ottica grandangolare, fino alle estremità dei rami della "Fibra Biforcata" o delle fibre uscenti dal "Separatore di Fascio Ottico a Polarizzazione" (Figura 1). Le suddette caratteristiche dovranno essere riferite ad un numero minimo di cinque (5) diversi angoli di incidenza, inclusi la mezzeria (0°), le due bisettrici del semi campo ($\pm\theta/4$) e gli estremi ($\pm\theta/2$) del campo visivo θ . La massima attenuazione ammissibile per l'insieme del "Complesso Assemblato" e del "fiber splitter" o "beam splitter" [dall'ottica grandangolare in zaffiro, all'estremità dei rami uscenti dal separatore di fascio ottico (Figura 1)] non dovrà superare il 65 % nell'intero campo di lunghezze d'onda 250-4500 nm, e per qualsiasi angolo di incidenza interno al campo visivo.

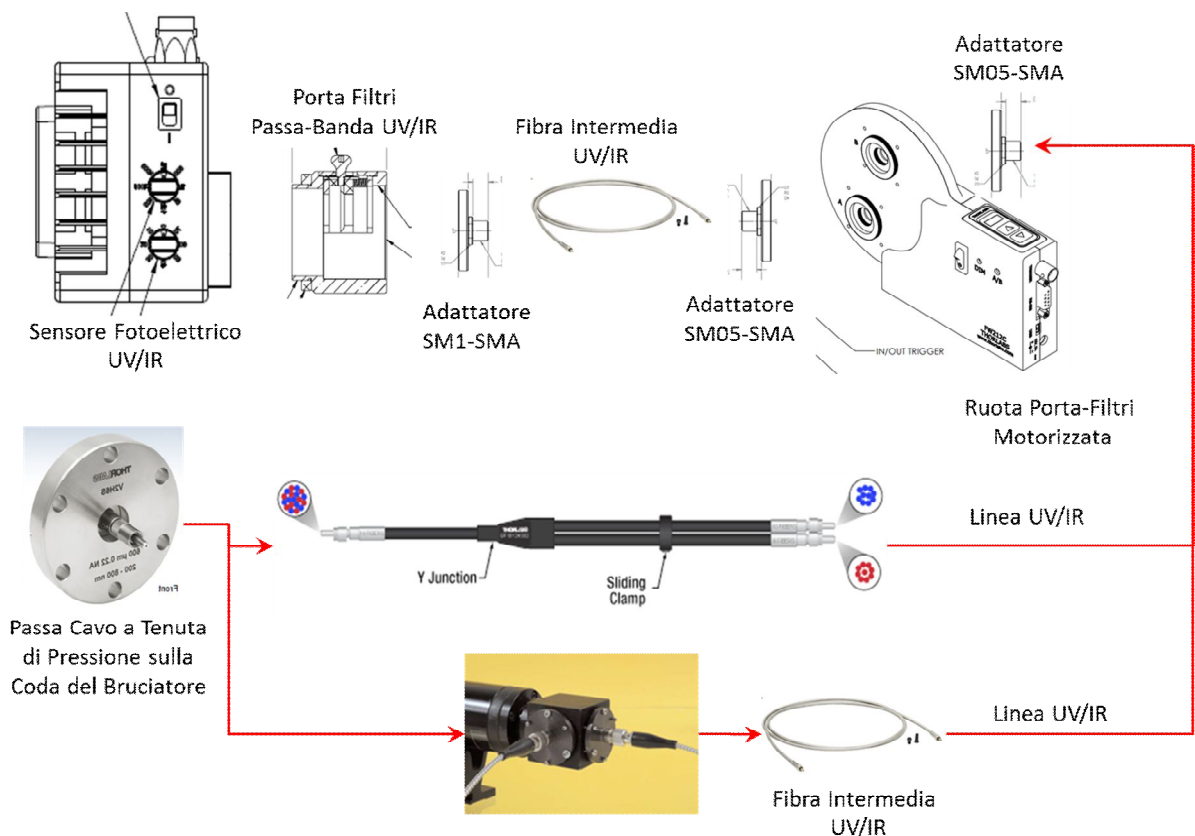




Figura 2

È auspicabile che le caratteristiche di risposta spettrale simulate si estendano fino all'interfacciamento con i sensori foto-elettrici, includendo, oltre alla sonda, tutti gli elementi funzionali interposti tra la sonda stessa ed il sensore (Figura 2): dalle fibre intermedie, agli adattatori, ai filtri grigi alloggiati nelle ruote motorizzate, ai filtri passa-banda disposti subito a monte del sensore fotoelettrico. Qualora ciò non fosse possibile, per tutti gli elementi non inclusi nella simulazione dovranno essere preliminarmente trasmesse le curve di risposta spettrale "da catalogo", per accettazione ad insindacabile giudizio di Co.Svi.G.. La disponibilità a fornire le caratteristiche di risposta spettrale attese, darà diritto ad una quota parte del punteggio assegnato all'offerta del "Fornitore", secondo quanto descritto nel "Disciplinare di Gara".

Quale ulteriore requisito opzionale è richiesto al "Fornitore" di eseguire, eventualmente avvalendosi di un laboratorio esterno certificato, la caratterizzazione della catena di misura ottica (estesa a tutte le parti di cui al punto precedente, anche quelle eventualmente escluse dalla simulazione), ossia la verifica sperimentale delle capacità di focalizzazione e delle caratteristiche di risposta spettrale "attese". La massima attenuazione ammissibile per l'insieme del "Complesso Assemblato" e del "fiber splitter" o "beam splitter" [dall'ottica grandangolare in zaffiro, all'estremità dei rami uscenti dal separatore di fascio ottico (Figura 1)] non dovrà superare il 65 % nell'intero campo di lunghezze d'onda 250-4500 nm, e per qualsiasi angolo di incidenza interno al campo visivo. La disponibilità a produrre la caratterizzazione di cui sopra, darà diritto ad una quota parte del punteggio assegnato all'offerta del "Fornitore", secondo quanto descritto nel "Disciplinare di Gara".

7. Una "Catena di Misura Esterna" in due rami, così composti:



- Un³ adattatore SM05-SMA [Figura 2, Allegato C.1)] per la connessione della fibra in arrivo alla ruota porta-filtri motorizzata (ramo uscente dal "fiber splitter" o dal "beam splitter").
- Una ruota porta-filtri motorizzata [Allegato C.2)] con il relativo sistema di alimentazione, supporto ed ancoraggio.
- Un kit di filtri grigi con Densità Ottica (OD, Optical Density) tra 0.1 e 1.0 [Allegati C.3-A), C3-B) e C.4)], da disporre nell'apposita ruota.
- Un Adattatore SM05-SMA per la connessione della Fibra UV/IR uscente dalla ruota porta filtri [Figura 2, Allegati C.5) e C.6)].
- Un adattatore SM1-SMA per la connessione della fibra UV/IR in arrivo al porta filtri passa-banda [Allegato C.1) e Figura 2].
- Una serie di filtri passa-banda [Allegati C.7) e C.8)], da disporre nel relativo portafiltri.
- Un porta filtri passa-banda a sostituzione manuale rapida [Allegato C.9)].
- Un sensore fotoelettrico a fotodiode con giunzione GaP per la linea UV [Allegato C.10)].
- Un sensore fotoelettrico a fotodiode con giunzione InGaAs per la linea IR [Allegato C.11)].

La disponibilità a fornire anche i suelencati elementi della "Catena di Misura Esterna", darà diritto ad una quota parte del punteggio assegnato all'offerta del "Fornitore", secondo quanto descritto nel "Disciplinare di Gara".

Tutte le connessioni intermedie dovranno essere realizzate con connettori SMA 905. Il fornitore è comunque tenuto a verificare la

³ La descrizione s'intende riferita a ciascuna linea UV od IR, pertanto, salvo diverso avviso, ogni elemento funzionale menzionato è da intendersi in due unità, con caratteristiche di risposta spettrale adatte ai diversi campi di lunghezze d'onda più sopra dichiarati per le due linee.

possibilità di corretto interfacciamento dei componenti suelencati e l' idoneità d'impiego degli stessi nei campi di lunghezze d'onda più sopra dichiarati per le due linee. Il fornitore è anche tenuto a verificare la necessità di collimatori del fascio ottico in corrispondenza ad ogni giunzione intermedia [a puro titolo esemplificativo un possibile assetto e illustrato in Figura 3 ed Allegati C.12)÷C.15)]

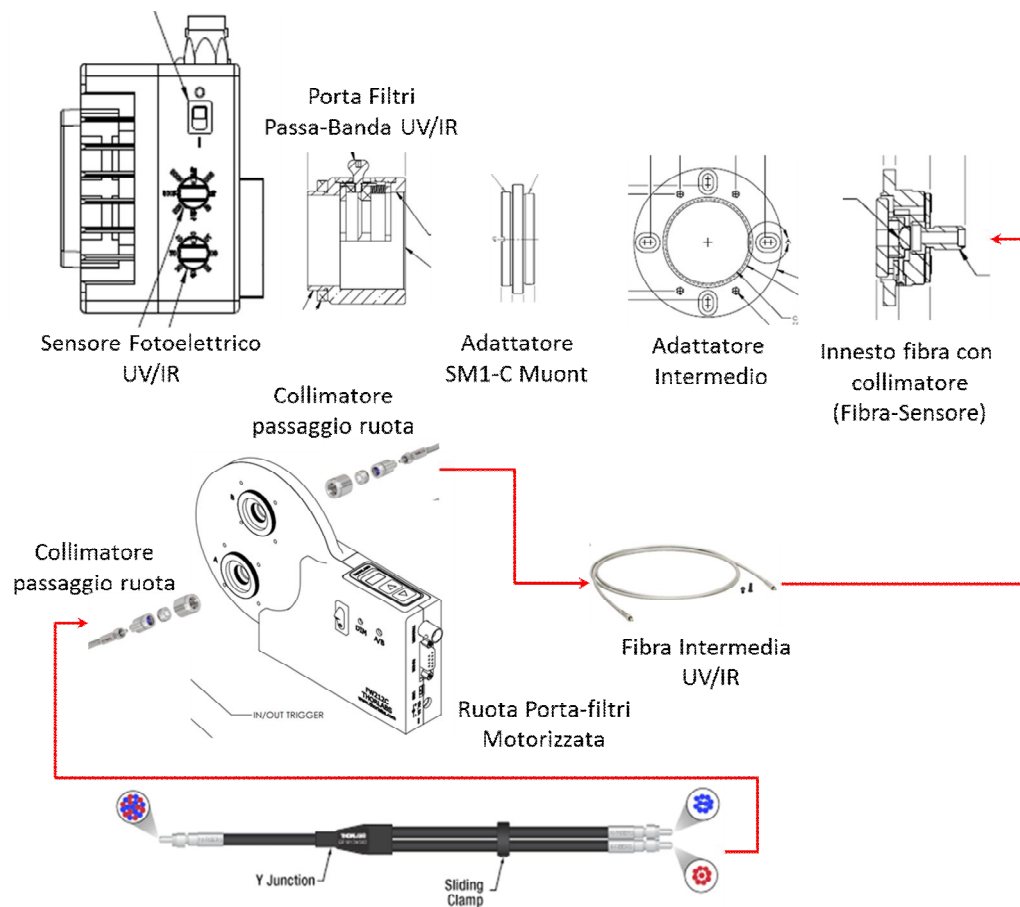


Figura 3

In una prima fase di validazione del sistema, tutta la componentistica a valle del "beam splitter" o del "fiber splitter" ("Catena di Misura Esterna") verrà fornita da un ente di ricerca terzo, già integrata con il relativo sistema di gestione (controllo, acquisizione dati ed analisi del segnale, che si interfaccia con il sensore foto-elettrico, per la regolazione del guadagno, e la ruota porta-filtri motorizzata). Successivamente, la collaborazione con il

suddetto ente si limiterà all'uso da parte di Sesta LAB del sistema di gestione, mentre sarà onere di Co.Svi.G. approvvigionare tutto quanto intercorre tra "splitter" e sensore fotoelettrico (incluso). Pertanto, i componenti inizialmente concessi in uso devono intendersi come assieme delle parti di ricambio per la preesistente "Catena di Misura Esterna", che dovranno essere acquisite da Co.Svi.C. S.c.r.l.. Per sufficiente garanzia di compatibilità è indispensabile che detta componentistica risponda in tutto e per tutto alle schede tecniche di cui agli allegati C.1)÷C.11). Fanno eccezione le fibre intermedie, UV ed IR tra ruota portafiltri e portafiltri a sostituzione rapida, che il fornitore provvederà a selezionare nella più opportuna forma di fibra singola o di bundle, ferme restando le specifiche sui materiali ottici sopra riportate.

8. Farà parte della fornitura anche un'apposita custodia per il trasporto del "Complesso Assemblato". La custodia avrà forma di una valigia provvista di materiale interno anti-urto, nel quale saranno ricavate le apposite sedi per l'alloggiamento del "Complesso Assemblato" in tutte le sue parti.

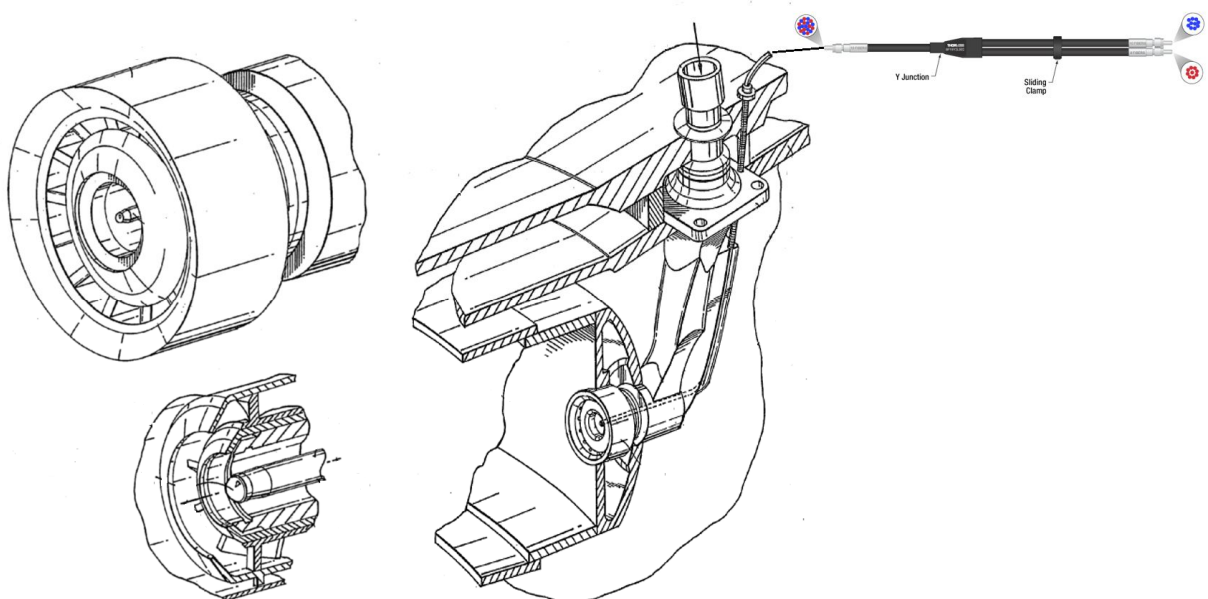


Figura 4



In una seconda forma realizzativa, nel seguito "Esecuzione 2" (Figura 4), la Sonda Ottica, fermo restando lo schema funzionale in precedenza descritto, verrà adattata per l'inserimento in un bruciatore di derivazione aeronautica. L'angolo visivo della sonda dovrà essere valutato dopo aver definito l'effettiva posizione dell'ottica in zaffiro, accorciando opportunamente il bordo d'uscita del "Center-body" [Allegato B)]. Per i materiali di cui in Figura 2, dal "fiber splitter" al sensore foto-elettrico (inclusi), restano intese le stesse condizioni già descritte per l'Esecuzione 1.

Il bruciatore [Allegato B)] verrà messo a disposizione dal "cliente" e reso accessibile al fornitore presso Sesta LAB per il prelievo. Eseguite le necessarie lavorazioni di assemblaggio dell'ottica, telaio, fibra e passacavo, il "Fornitore" provvederà a recapitare il "Complesso Assemblato", completo in tutte le sue parti, presso Sesta LAB.

Per entrambe le esecuzioni sarà cura del Fornitore procedere alla stesura del Fascicolo Tecnico del "Complesso Assemblato⁴". In ambito sperimentale, la certificazione PED (Pressure Equipment Directive 2014/68/UE) dei bruciatori non è obbligatoria. Tuttavia, per maggior garanzia di affidabilità, Co.Svi.G. S.c.r.l. intende valutare anche la categoria PED del "Complesso Assemblato" e la fattibilità tecnico-economica della relativa certificazione. Sarà quindi facoltà del "Fornitore" procedere alla quotazione della certificazione PED, che, se prodotta, comporterà un punteggio addizionale in termini di valutazione dell'offerta (vedere "Disciplinare di Gara"). Il costo della PED non dovrà determinare eccedenza dell'offerta complessiva sulla base di gara.

In caso di accettazione del preventivo PED da parte di Co.Svi.G. S.c.r.l., il "Fornitore" si dovrà organizzare affinché la certificazione PED sia svolta. Il "Complesso Assemblato" dovrà essere certificato nella completezza di tutti i suoi componenti come un unico manufatto a marchio CE. Il Fornitore



dovrà quindi:

- Procedere all'esecuzione a regola d'arte del "Complesso Assemblato", in entrambe le esecuzioni, secondo quanto sopra precisato.
- Utilizzare solo materiali (tubi, flange, elettrodi, etc..) accompagnati dalla relativa certificazione.
- Adottare procedimenti di saldatura rispondenti allo stato dell'arte nel relativo ambito tecnologico.
- Far eseguire le saldature da personale qualificato, allegando i certificati di qualifica (Welding Operator Qualification Test Certificate) degli operatori incaricati, nonché accludere il WPS (Welding Procedure Specification) delle saldature.
- Far eseguire i CND (Controlli Non Distruttivi) delle saldature da un organismo terzo, consegnando a Sesta LAB il relativo certificato (100% con liquidi penetranti, radiografie per le saldature di testa e quanto altro necessario per la certificazione secondo normativa PED 2014/68/UE). Il Fornitore comunicherà il laboratorio scelto per i CND a Sesta LAB, prima dell'esecuzione degli stessi controlli. Co.Svi. G. S.c.r.l., si riserva di accettare il laboratorio proposto a suo insindacabile giudizio. Il certificato attestante l'esito dei controlli dovrà essere trasmesso a Co.Svi.G. S.c.r.l..
- Allestire, eventualmente presso un'officina meccanica esterna, la prova idraulica per del "Complesso Assemblato" in tutte le sue parti, secondo i dati di progetto elencati in Figura 1. Il Fornitore ne darà evidenza inoltrando a Sesta Lab il certificato di avvenuta prova idraulica.
- Compilare il Fascicolo Tecnico e certificare il "Complesso Assemblato" secondo la norma PED 2014/68/UE, risultandone il fabbricante. In alternativa, il "fabbricante", sempre secondo normativa PED

⁴ D'ora innanzi, salvo diverso avviso, il "Complesso Assemblato" s'intenderà in entrambe le



2014/68/UE, potrà essere designato dal "Fornitore", tra le ditte appartenenti alla filiera produttiva del "Manufatto". L'approvazione del "fabbricante" designato dal fornitore sarà ad insindacabile giudizio di Co.Svi.G. S.c.r.l.). Gli oneri della certificazione sono a carico del Fornitore, che provvederà alla scelta dell'Organismo Notificato. È richiesto che l'appaltatore fornisca una copia completa del fascicolo tecnico per la certificazione PED a Sesta Lab, sia in forma cartacea che elettronica.

- Fornire a Co.Svi.G. S.c.r.l. i disegni CAD, 2D e 3D, del manufatto oggetto della presente specifica, in formato ".dwg". I disegni s'intendono comprensivi degli esecutivi di progetto e dei corrispondenti aggiornamenti a seguito dello "As Built" (questa richiesta dovrà essere soddisfatta che si proceda o meno alla certificazione PED).

Sono infine obbligatoriamente richiesti:

Il collaudo congiunto del "Complesso Assemblato", nelle condizioni di pieno carico del combustore (vedere temperature e pressioni operative riportate in Figura 1), presso Sesta LAB.

La consegna a Co.Svi.G. dell'intera documentazione relativa: ai disegni di progetto in formato CAD 2D e 3D, alle simulazioni numeriche preliminari ed alla successiva caratterizzazione. I disegni s'intendono comprensivi degli esecutivi di progetto e dei corrispondenti aggiornamenti a seguito dello "As Built".

Le descrizioni riportate nella presente specifica hanno valore esplicativo e non limitativo, pertanto deve intendersi compreso, anche se non espressamente indicato, tutto l'occorrente per realizzare a regola d'arte quanto è oggetto della richiesta. Il prodotto fornito dovrà essere completo,



finito in ogni parte ed idoneo all'impiego cui è destinato, del quale il Fornitore dichiara di essere a perfetta conoscenza.

Tutte le attività relative alla realizzazione del "Complesso Assemblato" dovranno essere condotte nel rispetto delle norme di sicurezza vigenti. Tutte le operazioni avverranno sotto la responsabilità diretta del Fornitore che provvederà al coordinamento interno delle attività. Per tali attività sono a carico del Fornitore i materiali, le attrezzature, le strutture necessarie, le giornate di lavoro, i tempi, i costi di viaggio ed il vitto del personale necessario.

Co.Svi.G. S.c.r.l. (Sesta LAB) dovrà essere informata per iscritto ogni 14 giorni solari sul progresso dei lavori e su eventuali criticità incontrate.

3. TEMPI DI CONSEGNA

Il Fornitore dovrà consegnare il "Complesso Assemblato" certificato PED (se previsto), entro e non oltre 30 settimane a partire dalla data di aggiudicazione della presente gara d'appalto. Co.Svi.G. S.c.r.l. trasmetterà i disegni CAD della lancia dell'olio (Realizzazione 1), o del bruciatore Aero-derivato (Realizzazione 2) dopo l'aggiudicazione della gara. Successivamente, il "Fornitore" potrà accedere in Sesta LAB per il prelievo della lancia dell'olio (Esecuzione 1) ed il bruciatore (Esecuzione 2), da equipaggiare con la componentistica ottica. La data a partire dalla quale detto accesso sarà garantito, presumibilmente a partire da Gennaio 2018, verrà comunicata in un secondo momento.

4. IMBALLO E TRASPORTO

L'ordine si intende porto franco, quindi comprendente tanto il prelievo della lancia dell'olio (Esecuzione 1) e del bruciatore (Esecuzione 2), presso l'area sperimentale di Sesta LAB, tanto la successiva riconsegna del "Complesso Assemblato" nel medesimo sito. Analogamente tutti i componenti della "Catena di Misura Esterna", eventualmente dopo la caratterizzazione in laboratorio, se inclusa, dovranno essere consegnati a Sesta LAB. Sono da ritenersi inclusi anche i materiali per l'imballaggio



necessari a garantire lo svolgimento del trasporto in sicurezza e l'integrità del manufatto in entrambi i viaggi da e verso Sesta LAB.

5. CONTROLLI

CO.SVI.G si riserva di presenziare, tramite i suoi incaricati, alle varie fasi della lavorazione, alla esecuzione dei controlli, alle eventuali prove idrauliche in presenza dell'ente notificato ed alle operazioni di montaggio.

6. GARANZIA

Il Fornitore dovrà sostituire o riparare gratuitamente quelle parti che dovessero rivelarsi difettate, non conformi ai disegni o danneggiate nel periodo di vigenza della garanzia precisato nei documenti contrattuali, per cause non imputabili a CO.SVI.G.. L'intera fornitura sarà garantita per 24 mesi dalla data di ultimazione dei lavori.

7. ALLEGATI

- A) Esecuzione 1: Lancia dell'Olio.
- B) Esecuzione 2: Bruciatore Aeronautico.
- C.1) Caratteristiche Adattatore SM05-SMA.
- C.2) Caratteristiche Ruota Porta Filtri Motorizzata.
- C.3-A) Caratteristiche Tecniche dei Filtri Grigi UV (Assorbenti).
- C.3-B) Filtri Grigi UV (Riflettenti).
- C.4) Filtri Grigi IR.
- C.5) Fibra Intermedia UV.
- C.6) Fibra Intermedia IR.
- C.7) Filtri Passa-banda UV.
- C.8) Filtri Passa-banda IR.
- C.9) Portafiltri a Sostituzione Rapida.
- C.10) Sensore Foto-elettrico UV.
- C.11) Sensore Foto-elettrico IR.
- C.12) Collimatori UV (ruota porta filtri)
- C.13) Collimatori IR (ruota porta filtri)
- C.14) Collimatori UV (fibra-porta filtri-sensore)



- C.15) Collimatori IR (fibra-porta filtri-sensore)

Allegato A) Esecuzione 1 - Lancia dell'Olio

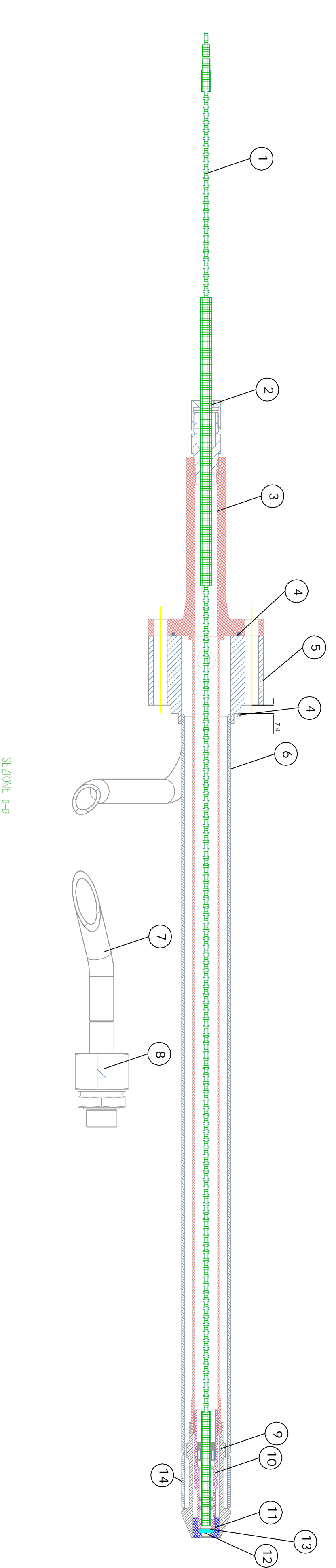
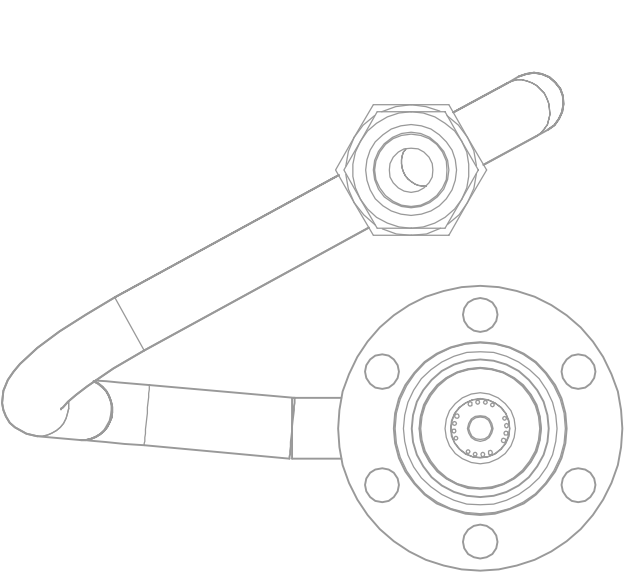
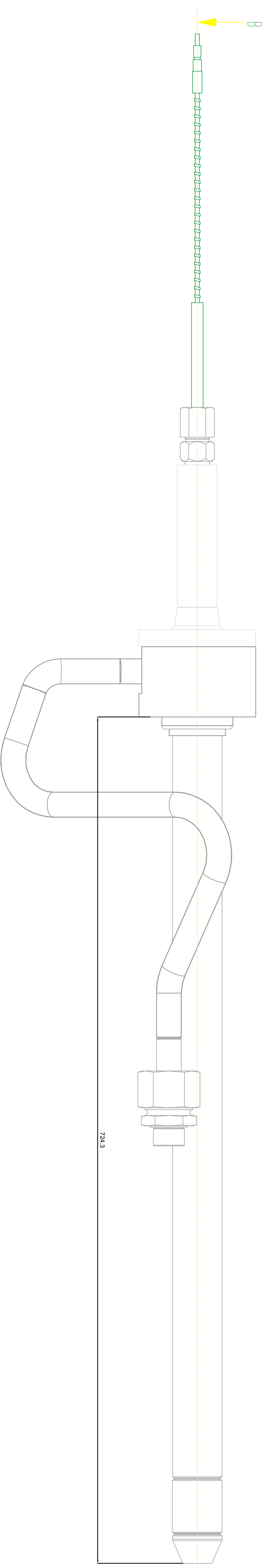
Attachment A) Realization1 - Fuel Oil Gun

Attachment A) Realization 1: Fuel Oil Gun Section Drawing.

Note that the present attachment shows a previous realization of the fuel oil gun full equipped with an internal fiber optic cable. It must be considered purely by way of example. Realization 1 must be executed strictly following the technical specification to which the present attachment refers. Once the tender will be assigned to a supplier, it will receive the fuel oil gun, emptied by the fiber optic cable, as well as more detailed drawings.

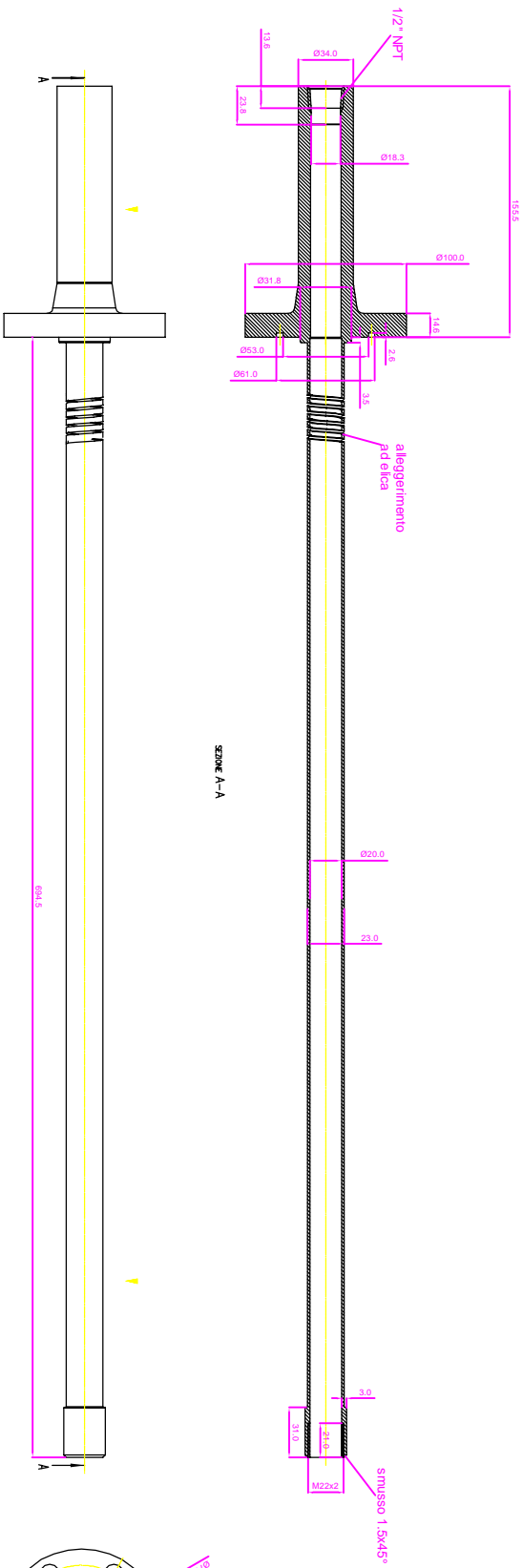
N.B.: Il presente allegato illustra una precedente realizzazione della lancia dell'olio, già completamente equipaggiata con un cavo interno di fibre ottiche. Quanto illustrato deve intendersi a puro titolo esemplificativo. Una volta assegnata la gara, il fornitore riceverà la lancia dell'olio svuotata dalla fibra ottica assieme con ulteriori e più dettagliati disegni.

Lancia DUMMY per FO: ASSIEME

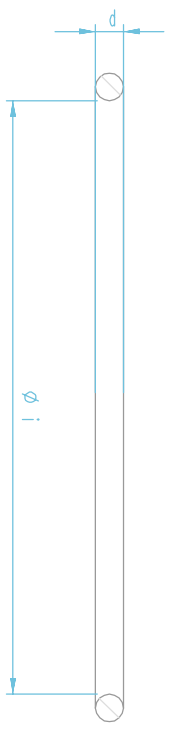


POS.	NOME COMPONENTE	NOTE	Materiali
1	fibra ottica		
2	CONAX	dis PG55-125-A-L	dis PG55-125-A-L
3	Lancetta con F.O.	come da disegno part. 3	CNI1118-10
4	Anello tenuta	come da disegno part. 4	NICr22Fe18Mo
5	Flangia	come da disegno part. 5	CNI1118-10
6	Asta	come da disegno part. 6	CNI1118-10
7	Tubo by-pass	modifica in officina di esistente	
8	AVIT	fornitura ASEN	
9	Testa	come da disegno part. 9	CNI1118-10
10	Canotto	come da disegno part. 10	CNI1118-10
11	Fondello	come da disegno part. 11	NICr22Fe18Mo
12	Quarzo	Thorlab quarzo 1/2" WG40530	
13	Feltrino	come da disegno part. 13	
14	Bussola	come da disegno part. 14	NICr22Fe18Mo

part. 3: lancetta con FO



POS. Item	DESCRIZIONE ANELLO Ring description	DIMENSIONE Dimension	Ø1 x Ø2 Ø1 x d
01	PROFIL A10	44±0.1 x 2	
02	PROFIL A10	54±0.1 x 3	
03	PROFIL A10	58±0.1 x 3	
04	PROFIL A10	64±0.1 x 3	
05	PROFIL A10	122±0.1 x 3	
06	PROFIL A10	34.5±0.1 x 2	
07			
08			
09			
10			
11			
12			



TOLLERANZE GENERALI IN ACCORDO A 426W378
General tolerances according to 426W378

Rev.	Sc.	Descrizione	Preparato	Controllato	Verificato	Verificato	Verificato	Approvato	Data
0		AGGIORNATO DATA SET Data set updated	0. Dall R0297	0della - R0298 105/0205				L. E. Inghile 9/105	12/12/14
rev. sc.		kind of revision	prepared	checked	verified	verified	verified	approved	date

Commiss./pr. no. _____ Codice identificativo _____
 Temperatura Code _____
 Iniziativa/issued by _____
 Conf. class _____
 Tipo doc./doc type _____
 Scala/grade _____
 Definito da/derived from _____
 Rev./rev. _____

ANSALDO ENERGIA

ANELLI DI TENUTA A10

Sealing rings A10

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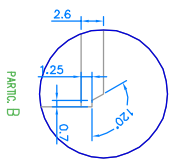
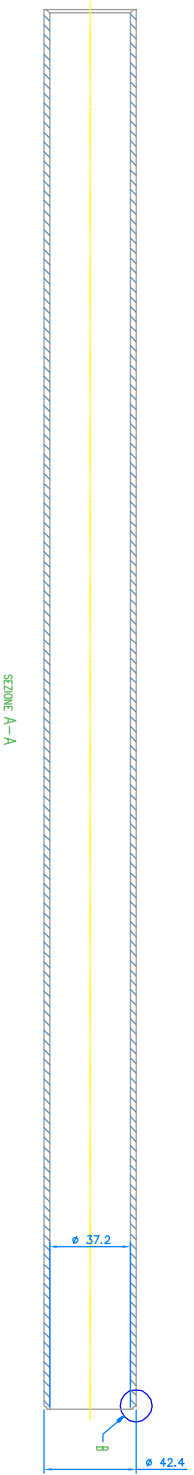
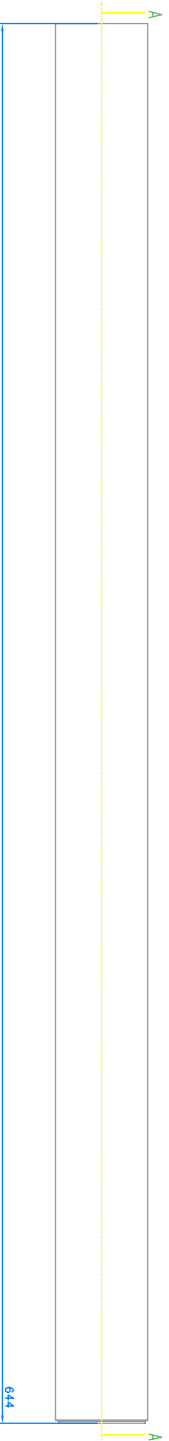
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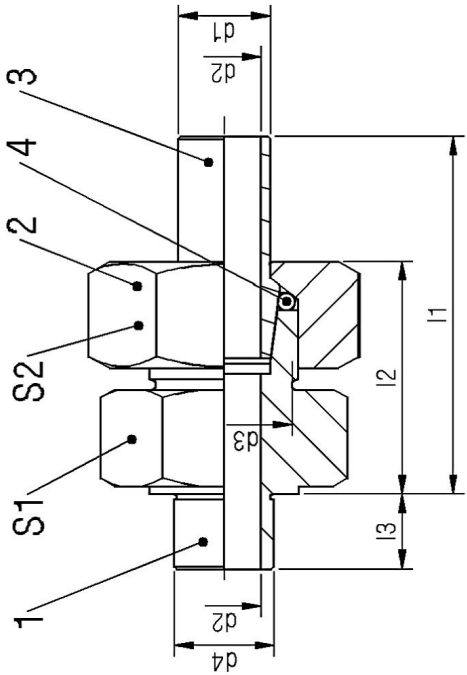
product break-down structure

413T458

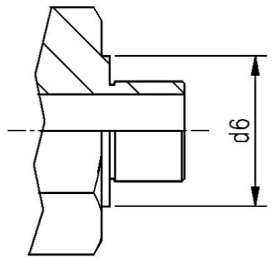
Rev./rev. _____
 Foglio _____
 Segno % _____
 del _____
 di _____

part. 6: asta





DN	ESTREMITA' DA SALDARE		FORMA B POS.	FORMA BU POS.	d ₃	d ₄	d ₅	d ₆	d ₇	d ₈	d ₉	d ₁₀	d ₁₁	d ₁₂	d ₁₃	d ₁₄	d ₁₅	d ₁₆	d ₁₇	d ₁₈	d ₁₉	d ₂₀	d ₂₁	d ₂₂	d ₂₃	d ₂₄	d ₂₅	d ₂₆	d ₂₇	d ₂₈	d ₂₉	d ₃₀	d ₃₁	d ₃₂	d ₃₃	d ₃₄	d ₃₅	d ₃₆	d ₃₇	d ₃₈	d ₃₉	d ₄₀	d ₄₁	d ₄₂	d ₄₃	d ₄₄	d ₄₅	d ₄₆	d ₄₇	d ₄₈	d ₄₉	d ₅₀	d ₅₁	d ₅₂	d ₅₃	d ₅₄	d ₅₅	d ₅₆	d ₅₇	d ₅₈	d ₅₉	d ₆₀	d ₆₁	d ₆₂	d ₆₃	d ₆₄	d ₆₅	d ₆₆	d ₆₇	d ₆₈	d ₆₉	d ₇₀	d ₇₁	d ₇₂	d ₇₃	d ₇₄	d ₇₅	d ₇₆	d ₇₇	d ₇₈	d ₇₉	d ₈₀	d ₈₁	d ₈₂	d ₈₃	d ₈₄	d ₈₅	d ₈₆	d ₈₇	d ₈₈	d ₈₉	d ₉₀	d ₉₁	d ₉₂	d ₉₃	d ₉₄	d ₉₅	d ₉₆	d ₉₇	d ₉₈	d ₉₉	d ₁₀₀	RACCORDO TUBO	PRESSIONE NORMALE	FORMA BU
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4	8.0	4	1	M18x1.5	G1/4A	18	18.9	48	31	12	19	22	8x2.0	*	13																																																																																										
8	13.5	8.3	2	M24x1.5	G1/2A	26	26.9	60	39	14	27	30	13.5x2.6	*	14																																																																																										
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15	21.3	17.3	5	M36x2.0	G1A	39	39.9	80	51	18	50	50	26.9x2.3	*	16																																																																																										
20	26.9	22.3	8	M42x2.0	G1 1/4A	49	49.9	89	57	20	55	60	33.7x2.6	*	17																																																																																										
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FORMA B
TYPE B

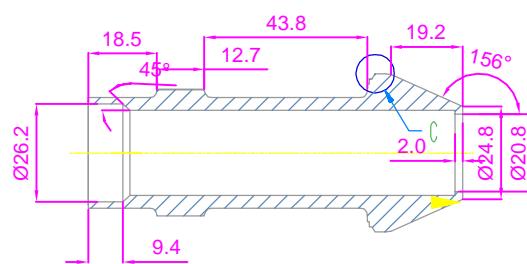
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TYPE BU

PER GUARNIZIONI SEC. DIN 7603
For seal in acc. to DIN 7603

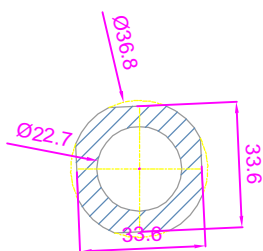
PER U-RING SEC. DIN 3869
For U-ring in acc. to DIN 3869

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Sc.	kind of revision	IP/ITGS				tes/gcos	tes/gcos	Verificato	Approvato	date	
Progetto/project			Tipo doc./doc.type			Scala/scale			Derivato da/derived from		
						1:1					
Commissa/job no.			Emittente/issued by			Classe riserv.			Confid. class		
			IP/ITGS			2					
Titolo			Titolo			RACCORDO AVIT			Avit union		
AnsaldoEnergia			AnsaldoEnergia			Ansaldo Energia s.p.a. si riserva tutti i diritti su questo documento che non può essere riprodotto neppure parzialmente senza la sua autorizzazione scritta.			Ansaldo Energia s.p.a. reserves all rights on this document that cannot be reproduced in any part without its written authorization.		
Codice struttura			Identificativo/document no.			402T974			Foglio sheet		
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			Rev./rev.			C			001		
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			DI			-			001		

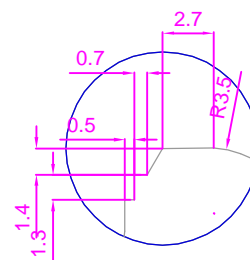
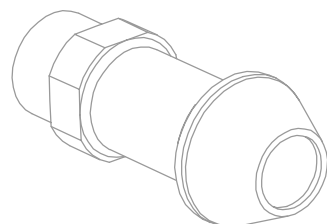
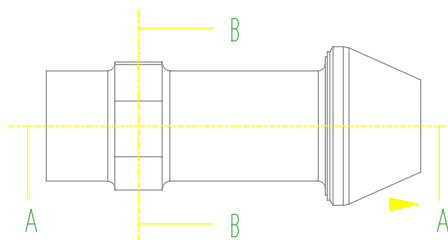
part. 9: testa



SEZIONE A-A

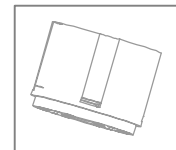
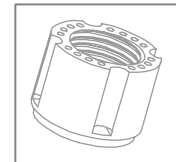
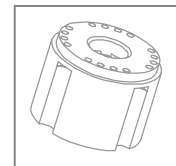
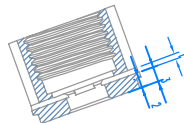
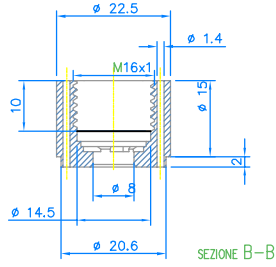
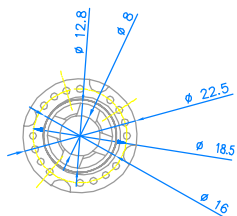
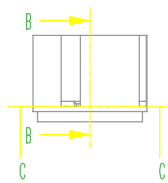
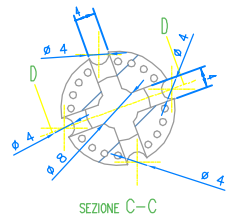
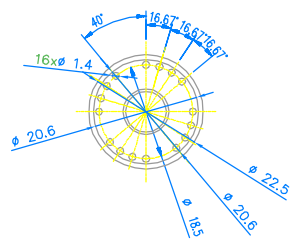


SEZIONE B-B



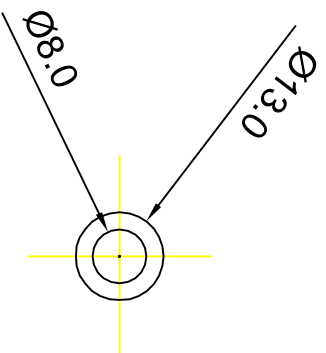
PARTIC. C

part. 11: fondello

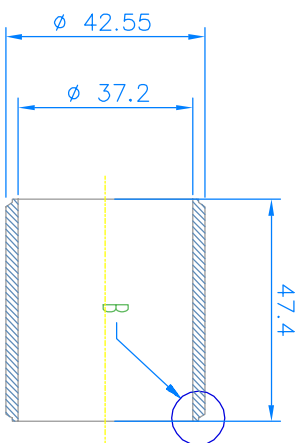
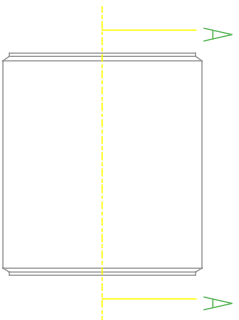


part. 13: feltrino

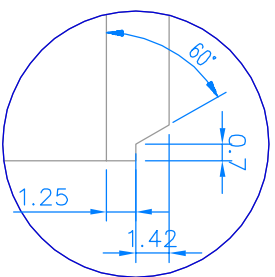
Alumina-Silica Fiber
Paper sp. 1mm



part. 14: bussola



SEZIONE A-A



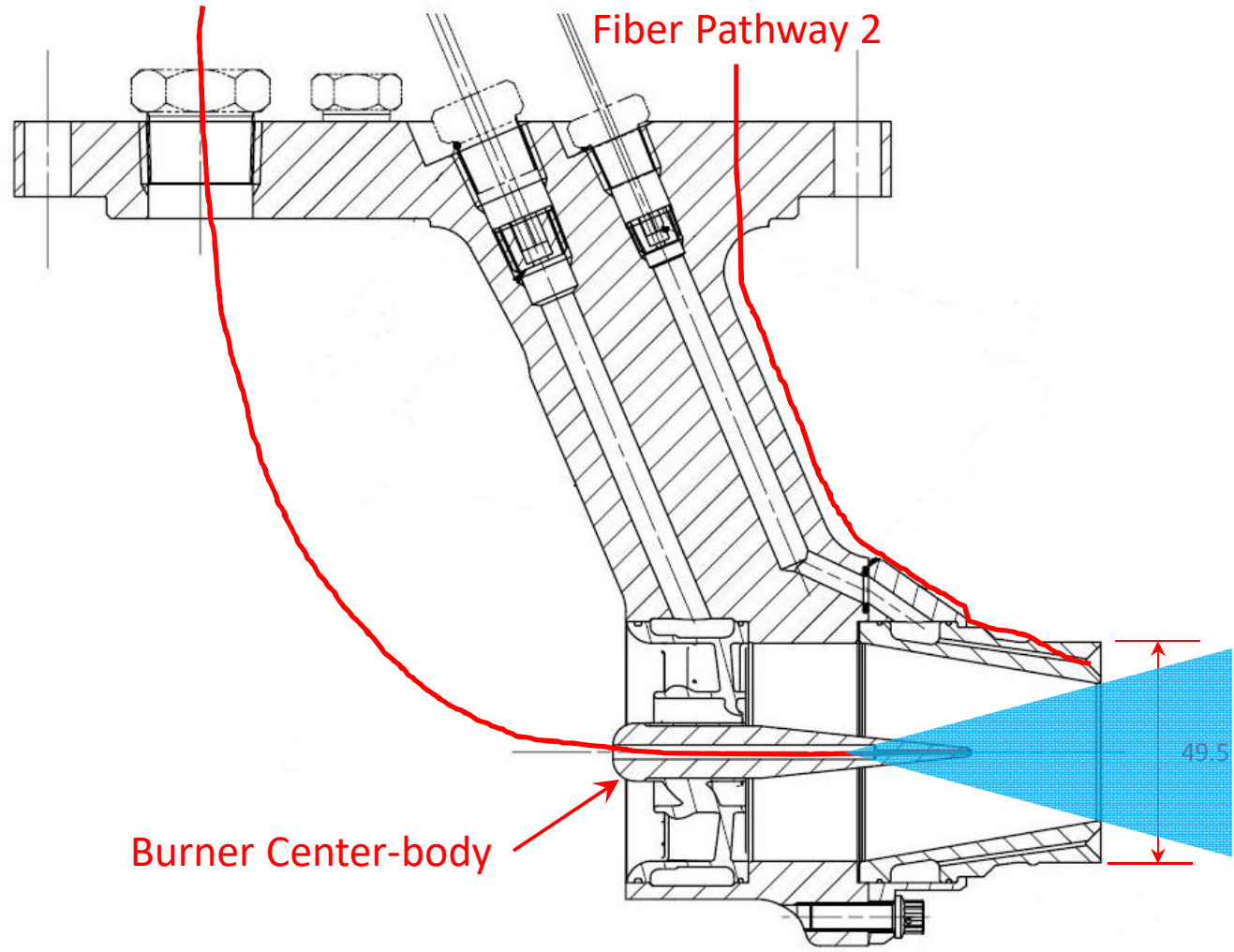
PARTIC. B

Allegato B) Esecuzione 2 - Bruciatore Aeronautico

Attachment B) Realization 2 - Aero-derivative Burner

Alternativa 1
Fiber Pathway 1

Alternativa 2
Fiber Pathway 2



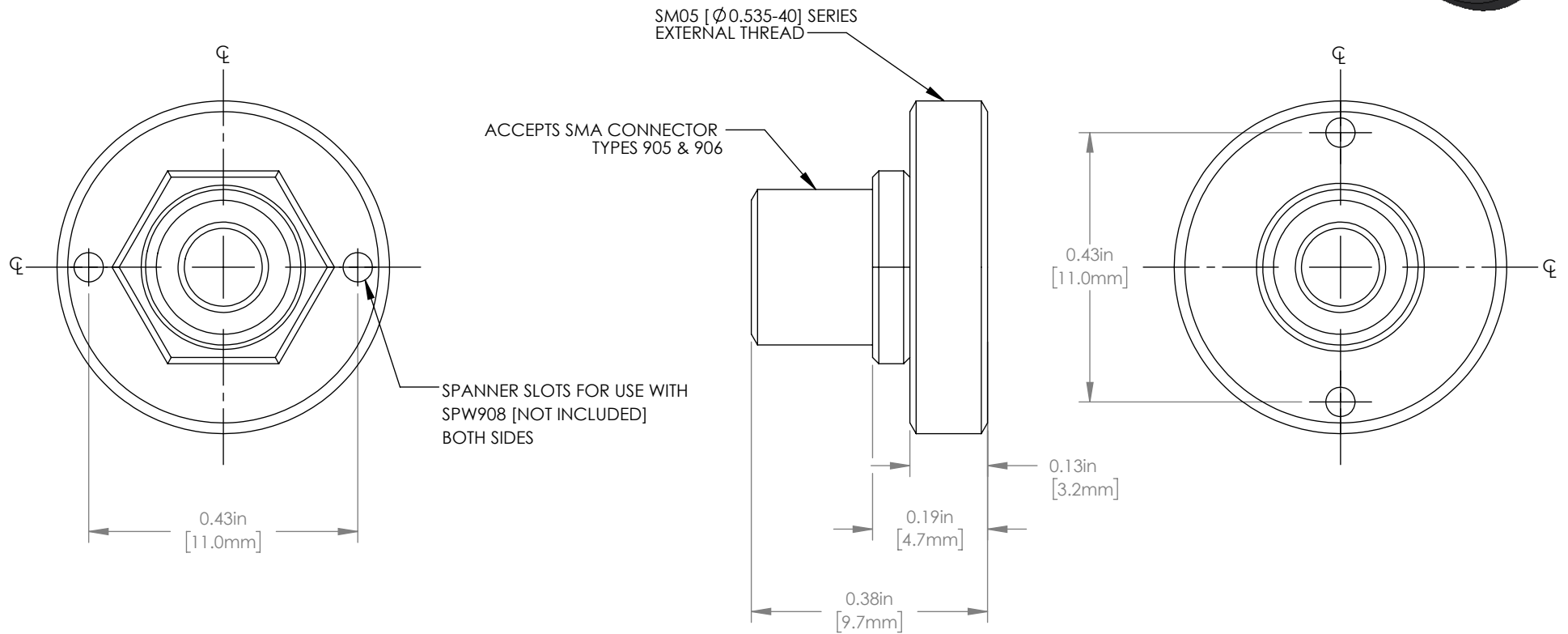
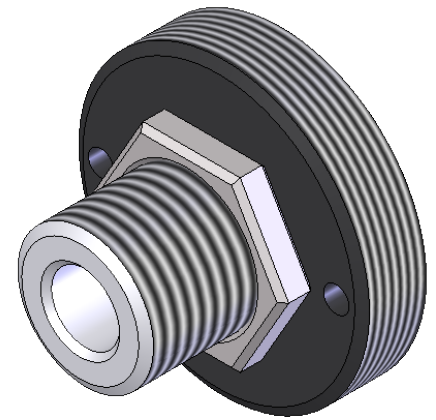
Burner Center-body

Viewing Angle
Angolo visivo

49.5

Allegato C1) Adattatore SM05-SMA e SM01-SMA

Attachment C1) SM05-SMA and SM1-SMA Adapter



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DRAWING PROJECTION

	NAME	DATE
DRAWN	AK	28/AUG/13
APPROVAL	SB	18/FEB/03

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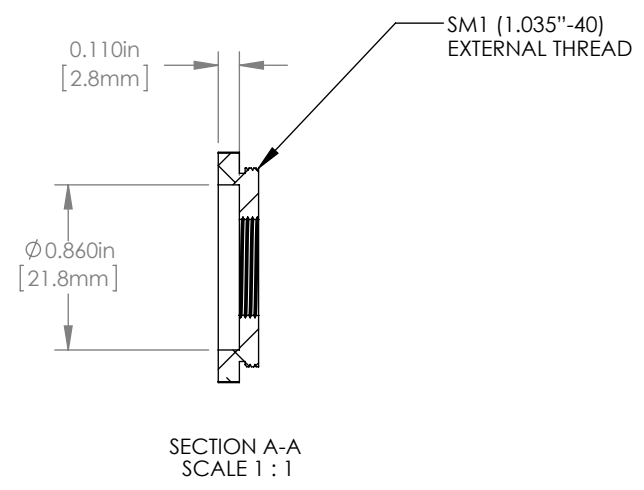
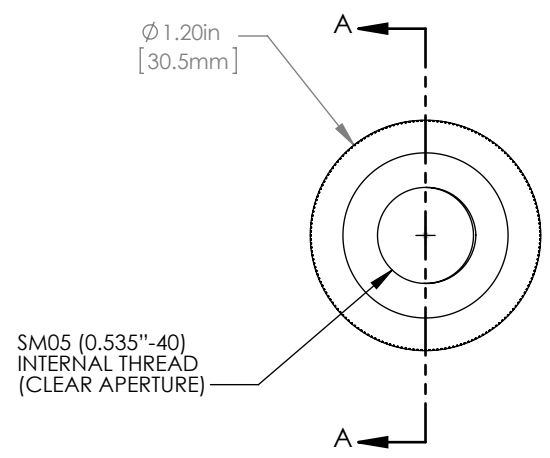
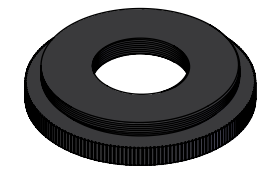
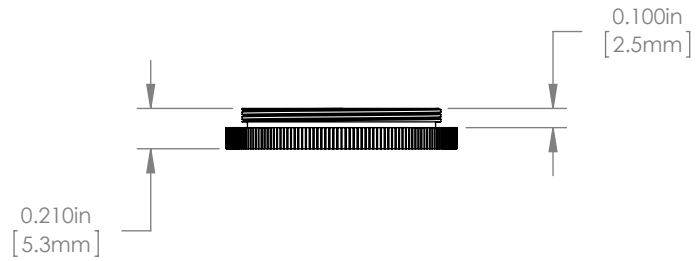
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS

THORLABS
www.thorlabs.com

SM05 TO SMA FIBER ADAPTER

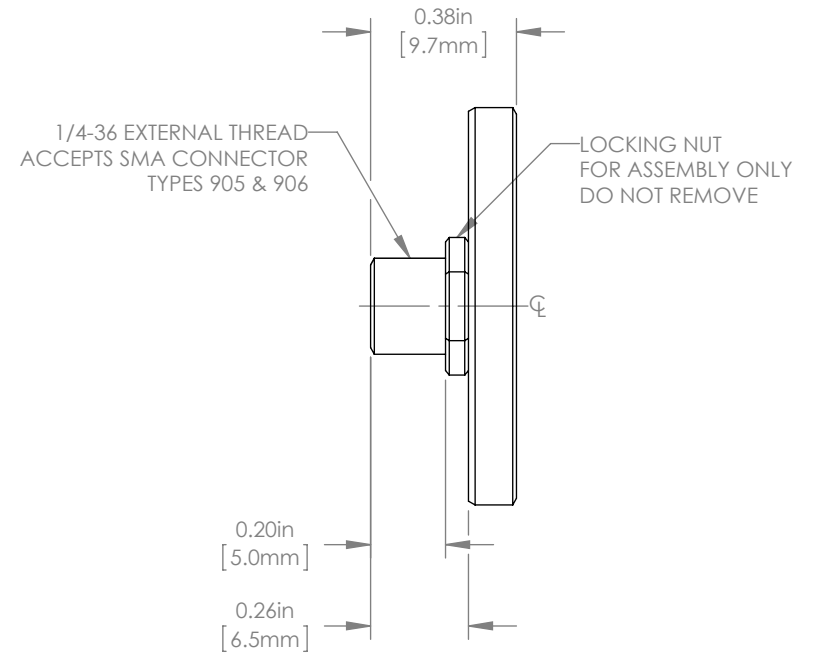
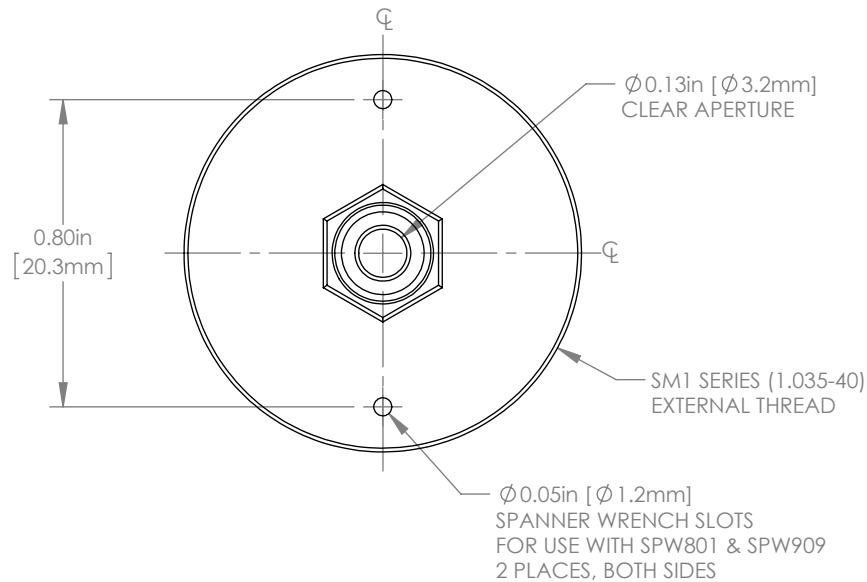
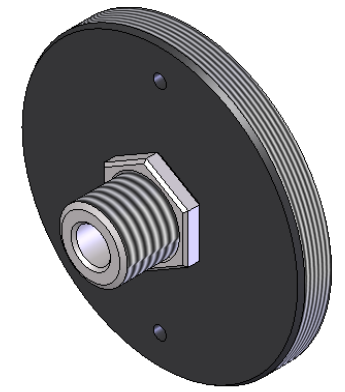
MATERIAL	N/A	REV B
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ITEM #	SM05SMA	APPROX WEIGHT	0.045 kg
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DRAWING PROJECTION			THORLABS www.thorlabs.com	
NAME	DATE	SM1 TO SM05 ADAPTER - KNURLED EDGE		
DRAWN TA	29/JAN/14	MATERIAL	ALUMINUM	REV A
APPROVAL ER	29/JAN/14	ITEM #	SM1A6FW	APPROX WEIGHT
COPYRIGHT © 2014 BY THORLABS				0.005 kg
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS				

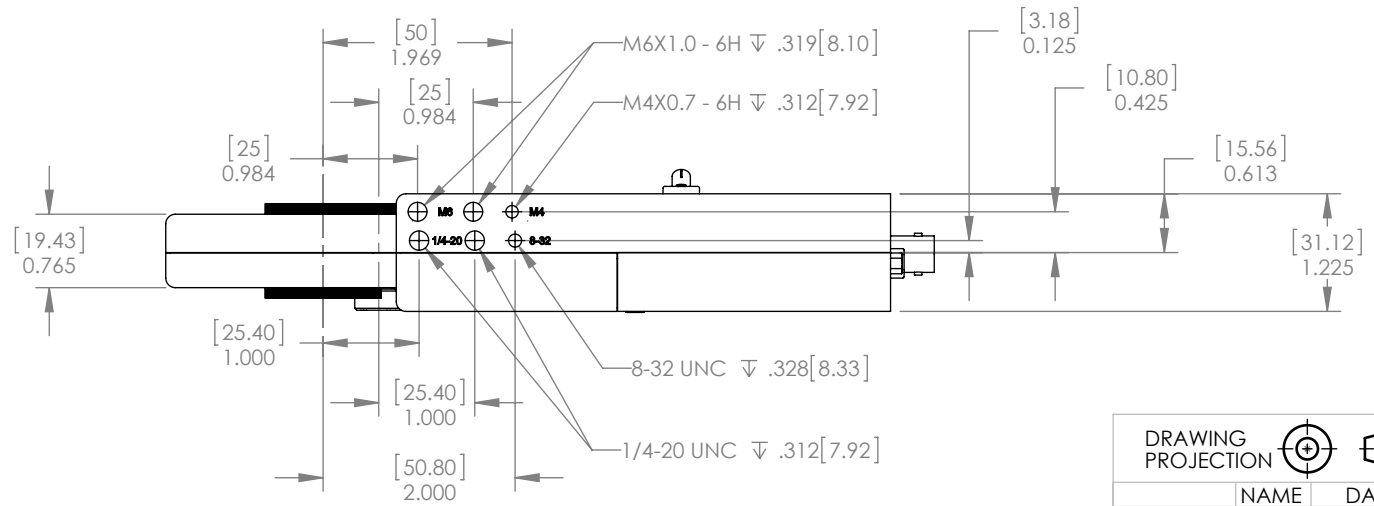
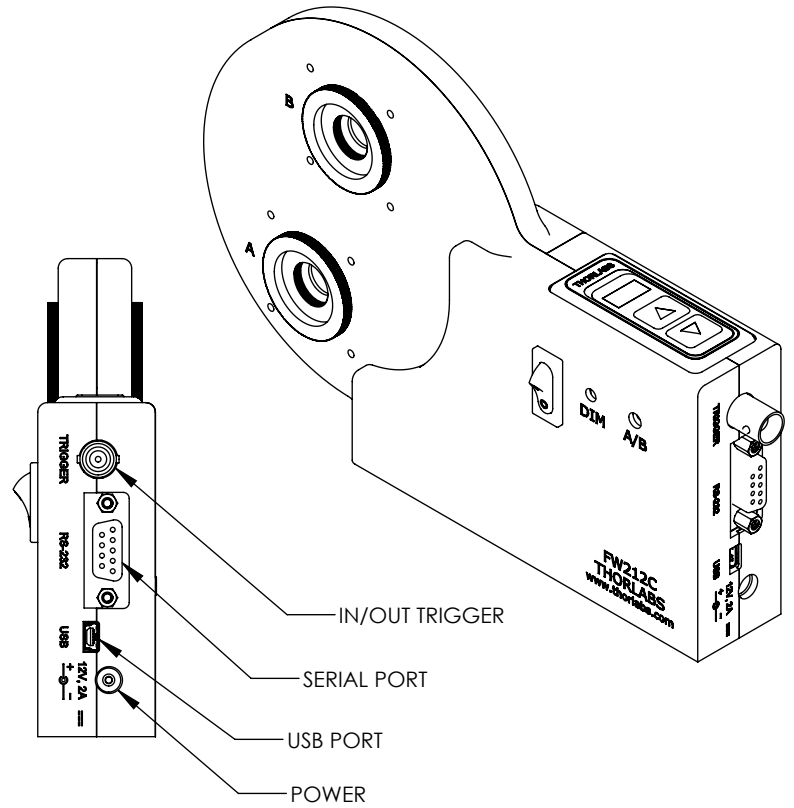
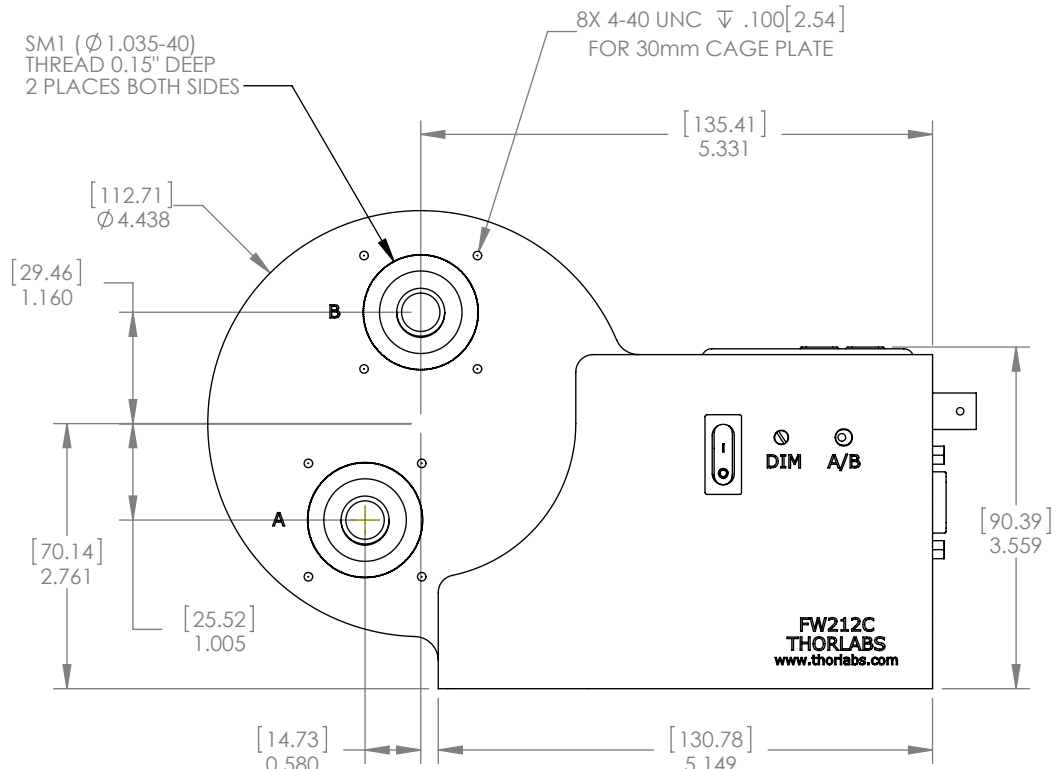


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DRAWING PROJECTION			THORLABS www.thorlabs.com SM1 ADAPTER FOR SMA FIBER CONNECTOR	
NAME	DATE			
REDRAWN	AV	20/JAN/15	MATERIAL	
APPROVAL	SR	16/JAN/95		
COPYRIGHT © 2015 BY THORLABS VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS			N/A	
ITEM #		SM1SMA	APPROX WEIGHT 7.3 g	
			REV	C

Allegato C2) Ruota Porta Filtri Motorizzata

Attachment C2) Motorized Filters Wheel



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DRAWING PROJECTION		
NAME	DATE	
DRAWN TA	02/19/14	
APPROVAL ER	02/19/14	
COPYRIGHT © 2010 BY THORLABS PROPRIETARY AND CONFIDENTIAL		
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS		

THORLABS www.thorlabs.com	
Filter Wheel	
MATERIAL	REV A
NA	
ITEM #	APPROX WEIGHT
FW212C	.75kg

THORLABS

FW102C, FW102CNEB, FW212C, FW212CNEB Motorized Filter Wheel

User Guide



















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Chapter 1 Warning Symbol Definitions

Below is a list of warning symbols you may encounter in this manual or on your device.

Symbol	Description
	Direct Current
	Alternating Current
	Both Direct and Alternating Current
	Earth Ground Terminal
	Protective Conductor Terminal
	Frame or Chassis Terminal
	Equipotentiality
	On (Supply)
	Off (Supply)
	In Position of a Bi-Stable Push Control
	Out Position of a Bi-Stable Push Control
	Caution: Risk of Electric Shock
	Caution: Hot Surface
	Caution: Risk of Danger
	Warning: Laser Radiation
	Caution: Spinning Blades May Cause Harm

Chapter 2 Safety

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly.



ATTENTION



Do not use the filter wheel in explosive environments.



ATTENTION



Filter wheel is not intended for use in an outdoor environment.



WARNING



Prior to opening, troubleshooting, changing filters or maintaining the unit, ensure that the power is off and the unit is disconnected from the DC source.

Original Instructions Written in English

These instructions were drafted in English. Thorlabs is not responsible for the content of any manual translated into another language.

Chapter 3 Description

The FW102C, FW102CNEB, FW212C, and FW212CNEB are high-precision, motor-driven filter wheels used for a host of applications, including color CCD photography, fluorescence microscopy, and photometry. The FW102CNEB and FW212CNEB are the same as the FW102C and FW212C, respectively, with preloaded filters. (See which filters on page 7)

All units consists of a control unit, filter wheel housing, and a removable Ø4" filter wheel. The FW102C Filter Wheel accommodates up to six Ø1" optical filters, while the FW212C can accommodate up to twelve Ø1/2" optical filters. **Note: The FW102CNEB and FW212CNEB Filters Wheels come with preloaded filters.**

Filter selection can be made manually from the push button controls on the display panel or remotely from a USB 2.0 interface, a serial port, or a TTL level active low (BNC) input. Both filter wheels contain an active display to indicate the selected filter: two separate aperture openings exist, the first opening at the top of unit 12 o'clock position or 0° and the second opening at the 7 o'clock position or 210° degrees. (see drawing on page 14)

All units are designed to ensure an accuracy of greater than $\pm 1^\circ$. The FW102C filter wheel housing easily mounts to our Ø1" lens tube systems and optical instruments via two SM1 (1.035"-40) threaded mounts. The FW212C housing includes four SM1A6FW SM1 to SM05 (0.535"-40) adapters for mounting our Ø1/2" lense tube systems. Other adapters are available to interface to other popular camera, microscope, and telescope thread sizes. All units are also compatible with Thorlabs' 30 mm cage systems; each port has the required four 4-40 tapped holes to mount the cage rods. They also also feature #8 and M6 tapped holes for mounting to steel posts. Two 1/4"-20 and M6 tapped holes allow the filter wheel to be mounted to a plate (See Drawing on Page 7). The flexible mounting system makes these filter wheels ideal for both instrument and laboratory applications.

All units come with a CD-ROM that contains a Windows™-based, standalone application program. Sample code is provided for LabVIEW™ and C++ code development. The filter wheels can also be controlled via a set of command line prompts using terminal server software, allowing users to create scripts in their own programs. The unit is powered via a 12 VDC input (converter supplied with unit).

3.1. Features

- Automated Computer Control Capability (Application Software Provided)
- Wheel Size: Ø4"
- Filter Wheel Options:
 - FW102C: 6-Position for Ø1" Filters
 - FW102CNEB: 6-Position with Preloaded Ø1" filters (See Page 8 for Included Filters)
 - FW212C: 12-Position for Ø1/2" Filters
 - FW212CNEB: 12-Position with Preloaded Ø1/2" Filters (See Page 8 for Included Filters)
- External Trigger In (Increment Control)
- External Trigger Out (Provisioned from Software)
- Bidirectional Controls
- Selectable Aperture Openings at 0° (12 o'clock position) and 210° (7 o'clock position)
- Dimmable Display

3.2. New Design

The FW102C and FW212C lines feature a new, more robust design compared to the older FW102B. The filter wheel is turned using a powerful and reliable stepper motor and worm gear. This design will provide millions of wheel changes over its life time.



ATTENTION



Due to play in the gears, some noise can be heard during operation and when moving or shaking the device. There are virtually no small parts that can come loose inside the device. This noise is normal and not indicative of a problem.

3.3. Shipping Inventory

The FW102C, FW102CNEB, FW212C and FW212CNEB are shipped with the following components respectively:

Part Description	Qty.	FW102C	FW212C	FW102CNEB	FW212CNEB
Controller with Filter Housing	1	✓	✓	✓	✓
6-Position Wheel, Ø1" Optics	1	✓	✗	✓	✗
12-Position Wheel, Ø1/2" Optics	1	✗	✓	✗	✓
SM1A6FW SM1 to SM05 Adapter	4	✗	✓	✗	✓
12 V DC Converter	1	✓	✓	✓	✓
Power Cord	1	✓	✓	✓	✓
USB Cable	1	✓	✓	✓	✓
SM1CP2 End Cap, SM1 Thread	2	✓	✗	✓	✗
SM05CP2 End Cap, SM05 Thread	2	✗	✓	✗	✓
SM1RR Retaining Ring	6	✓	✗	✓	✗
SM05RR Retaining Ring	12	✗	✓	✗	✓
NE501B Absorptive ND Filter	1	✗	✗	✗	✓
NE502B Absorptive ND Filter	1	✗	✗	✗	✓
NE503B Absorptive ND Filter	1	✗	✗	✗	✓
NE504B Absorptive ND Filter	1	✗	✗	✗	✓
NE505B Absorptive ND Filter	1	✗	✗	✗	✓
NE506B Absorptive ND Filter	1	✗	✗	✗	✓
NE510B Absorptive ND Filter	1	✗	✗	✗	✓
NE513B Absorptive ND Filter	1	✗	✗	✗	✓
NE520B Absorptive ND Filter	1	✗	✗	✗	✓
NE530B Absorptive ND Filter	1	✗	✗	✗	✓
NE540B Absorptive ND Filter	1	✗	✗	✗	✓
NE550B Absorptive ND Filter	1	✗	✗	✗	✓
NE05B Absorptive ND Filter	1	✗	✗	✓	✗
NE10B Absorptive ND Filter	1	✗	✗	✓	✗
NE20B Absorptive ND Filter	1	✗	✗	✓	✗
NE30B Absorptive ND Filter	1	✗	✗	✓	✗
NE40B Absorptive ND Filter	1	✗	✗	✓	✗



Figure 1 FW102C Filter Wheel System

Chapter 4 Basic Operation

The following sections describe the basic operation of the motorized filter wheels and application software.

4.1. Changing and Removing the Filters



WARNING



Prior to changing filters, ensure that the power is off and the unit is disconnected from the DC source.

The filters can be changed by first removing the filter wheel cover, which is held in place with a single thumbscrew. Filters can then be inserted into the desired locations for either a six- or twelve-position wheel. The filters for the six-position wheels are secured via SM1RR retaining rings, while the filters for the twelve-position wheel are secured using SM05RR retaining rings, all which are included with the specified unit. For easy access, the entire filter wheel can be lifted out of the filter wheel housing. Please note that the rear edge of the threaded filter holes contain a retaining lip that secures the edge of the filter (see figure 2). Some smaller filters may need to be mounted between two retaining rings to be properly secured.



Figure 2 Rear Retaining Lip

Thorlabs offers preloaded filter wheels if that is desired. The table below outlines which filters are included with each system, their optical density, and the position they are mounted in.

FW102CNEB			FW212CNEB		
Filter Item #	Optical Density	Position	Filter Item #	Optical Density	Position
Blank	N/A	1	Blank	N/A	1
NE05B	0.5	2	NE501B	0.1	2
NE10B	1.0	3	NE502B	0.2	3
NE20B	2.0	4	NE503B	0.3	4
NE30B	3.0	5	NE504B	0.4	5
NE40B	4.0	6	NE505B	0.5	6
-	-	-	NE506B	0.6	7
-	-	-	NE510B	1.0	8
-	-	-	NE513B	1.3	9
-	-	-	NE520B	2.0	10
-	-	-	NE530B	3.0	11
-	-	-	NE540B	4.0	12

Once the filter wheel has been populated with filters and properly installed, the process of reassembling the filter wheel goes as follows: slip the wheel over the shaft and turn slightly to allow the gears to mesh, replace the cover and tighten the thumb screw. It is not necessary to return the wheel to any particular orientation; the unit will reorient automatically when the power is turned on.

4.2. Mounting

The base of the unit contains an array of mounting holes for attaching to steel posts or directly to other mounting plates. See Figure 3 below for whole sizes and locations.

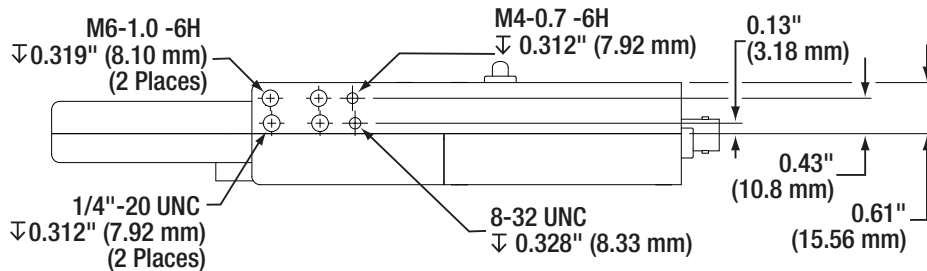


Figure 3 Filter Wheel Mounting Holes

The filter wheel cover contains SM1 threads for attaching lens tubes or for mounting the unit directly to cameras, microscopes, and telescopes. The filter wheel can be attached directly to Thorlabs' 30 mm cage systems via four 4-40 tapped holes that surround each port.

4.3. Power

The unit comes with an AC wall adapter to supply 12 VDC to the unit. Plug the 2.1 mm plug from the AC adapter into the DC input jack on the unit. The ON/OFF (0/1) switch is located on the side of the unit. Upon power up, the unit will display the filter number that is located at the selected aperture. If the wheel is not located at a valid location, it will rotate to the closest valid position.

Power Supply
Thorlabs Filter Wheel

Input Voltage Rating: 90-264 VAC, 47-63 Hz
Max Voltage Input: 12.6 V DC **Max Current Input:** 2.08 A

4.4. Aperture

The unit has two aperture locations labeled “A” and “B” for the 0° (12 o'clock position) and 210° (7 o'clock position), respectively (see Figure 3 below). The A/B switch on the side of the unit selects the aperture.

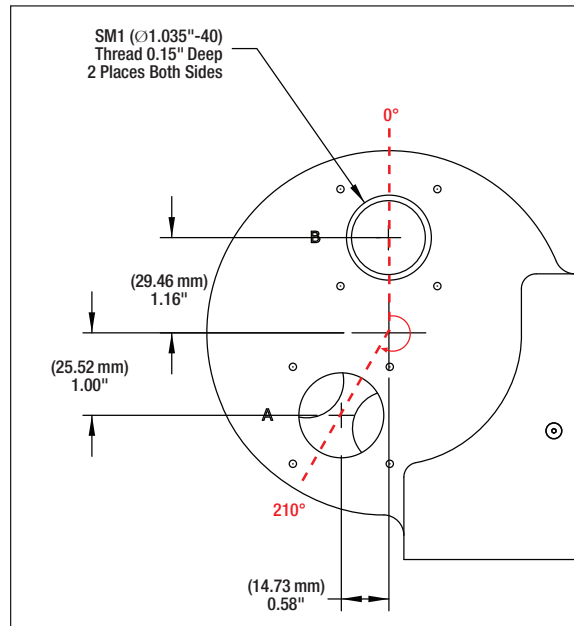


Figure 4 Filter Wheel Apertures

4.5. Manual Control

Pushing the ▲ / ▼ arrow buttons on the top of the unit will adjust the filter location. The arrows indicate the direction of the wheel's rotation, and the display will indicate the filter selection. The display brightness can be adjusted using a small screwdriver at the hole marked DIM (see figure 5).



Figure 5 DIM Display Brightness

4.6. External Trigger

The unit may be remotely triggered to advance to the next position. This is done by applying an active low pulse to the BNC trigger input. The input is TTL compatible and should not exceed 5 V. Because the input is internally pulled up, the trigger will operate with a passive connection to ground. The trigger mode defaults on power up to an input mode. Software provisioning can, however, change the trigger mode to an output mode. In the output mode, the unit generates an active high 10 ms pulse (TTL level) to indicate that the wheel has completed its rotation to the selected position. This pulse may be used to activate other equipment. The trigger can be changed to the output mode from the application software or by sending the command “Trig=1” over the USB interface.

Chapter 5 Software Control

5.1. Application Software Operation

The FW102C(NEB) and FW212C(NEB) come with a CD-ROM that contains application software to control the unit using USB 2.0, or RS232, from a PC. (See Thorlabs Motorized Filter Wheel Software Manual).

Minimum PC Requirements

The application program requires a minimum of a Pentium-class machine running Windows XP or newer.

5.2. Command Line Interface

The FW102C can also be controlled by a command line language through the USB or RS232 ports. This is offered to enable operation through a terminal interface or for those who may want to write their own program to control the wheel. Prior to running the command line interface, the unit should be powered, and a USB or RS232 cable should be connected between the FW102C and the host. The terminal emulator should be configured as follows:

Parameter	Setting
Baud Rate	115.2 K Bits per Second
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

If the connection is correct, you will see the following message after pushing the *Enter* key:

Command error CMD_NOT_DEFINED

This message will be followed immediately by the prompt:

>

The basic structure of the interface is a keyword followed by either an equals sign “=” or a question mark “?”. The “=” or “?” will determine if the string is a command or a query. All strings (commands and queries) must be terminated by a carriage return (CR) or pressing the ENTER key on the computer.

5.2.1. Command Structure

Keyword = argument (CR)

Here, *keyword* defines the function, and *argument* is a numerical value followed by a carriage return (CR).

5.2.2. Query Structure

Keyword? (CR)

Keyword defines the function, and the question mark (?) indicates a query. The string is terminated with a carriage return (CR). Exceptions to this and unique shortcut keys are given in the table on page 11.

The prompt symbol “>” will appear on power-up and after a command is accepted by the FW102C and indicates that the FW102C is ready to receive another command line.

5.2.3. Keywords (Commands and Queries)

The following table describes all of the available commands and queries:

Command	Syntax	Description
Get ID	*idn?	Returns the model number and firmware version
Set Position	pos=n	Moves the wheel to filter position n
Get Position	pos?	Position Query
Set Position Count	pcount=n	Sets the wheel type where n is 6 or 12
Get Position Count	pcount?	Returns the wheel type
Set Trigger Mode	trig=0	Sets the external trigger to the input mode
	trig=1	Sets the external trigger to the output mode
Get Trigger Mode	Trig?	Returns the trigger mode
Set Speed Mode	speed=0	Sets the move profile to slow speed
	speed=1	Sets the move profile to high speed
Get Speed Mode	speed?	Returns the move profile mode
Set Sensor Mode	sensors=0	Sensors turn off when wheel is idle to eliminate stray light
	sensors=1	Sensors remain active
Get Sensor Mode	sensors?	Returns the sensor mode
Set Baud Rate	baud=0	Sets the baud rate to 9600
	baud=1	Sets the baud rate to 115200
Get Baud Rate	baud?	Returns the baud rate where 0 = 9600 and 1 = 115200
Save Settings	save	This will save all the settings as default on power up

^aAll commands and queries are in lower case letters.

If the keyword, format, or argument are incorrect or out of range, the unit will return an error string.

In addition to the commands given above, there is also special functionality added to the arrow keys of the computer's keyboard:

Key	Description
Up Arrow	Increments the filter position by 1
Down Arrow	Decrements the filter position by 1

Chapter 6 Troubleshooting and Maintenance



WARNING



Prior to troubleshooting or maintaining the unit, ensure that the power is off and the unit is disconnected from the DC source.

Dust or debris can sometimes get into the filter wheel housing and block the sensors. This will result in the filter wheel failing to move to the desired position. To prevent this, periodically remove the filter wheel and use compressed air to clear away any contaminants. Externally the unit can be cleaned with a damp cloth to remove dust or debris.

6.1. Removing the Filter Holder

The filter holder may be tight and difficult to remove. To make the wheel release with the minimal of force, grab it on the right side (by filter position 5 in image below) and pull the wheel out and to the left as depicted by the large red arrow.

When reinserting the wheel, push the filter holder onto the post jiggling the holder clockwise and counterclockwise to help align the gears.

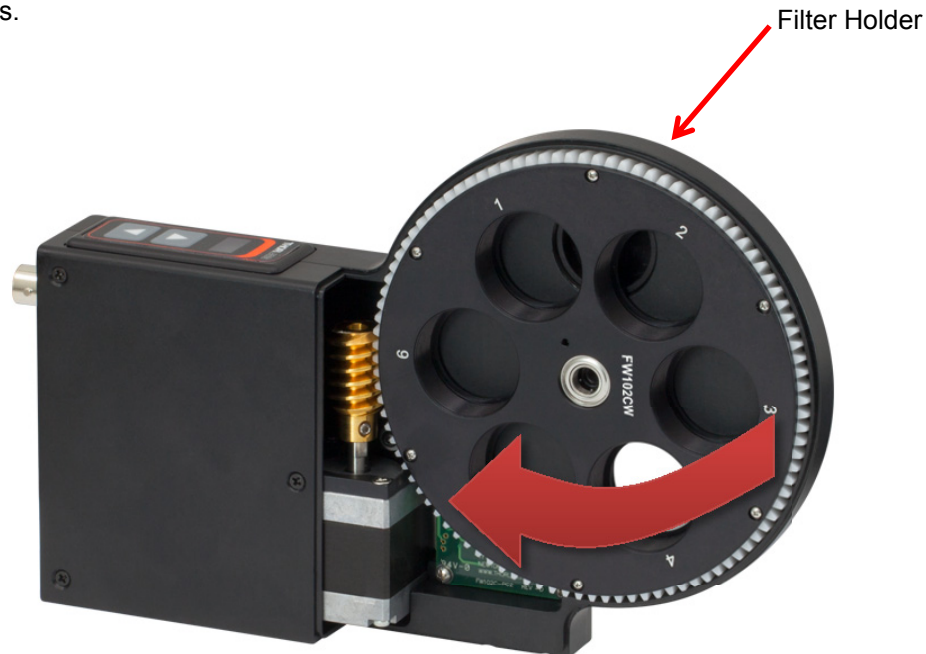


Figure 6 Open Filter Wheel

6.2. Changing Filter Wheel Types

When changing filter wheel types (i.e. from a 6- to 12-position wheel), the unit will need to be set to a mode that will correctly interpret the correct position of the wheel. To convert the unit from 6-position wheel operation to 12-position wheel operation, follow the steps below (process is similar for the other way around):

1. Unplug the power from the unit
2. Unscrew the thumbscrew and remove housing
3. Remove the 6-position wheel and insert the 12-position wheel
4. Reinstall the housing and secure with the thumbscrew
5. Plug the power cable back into the unit
6. Turn on the unit and select a position for the wheel other than 6 or 12
7. Hold down both arrow buttons until the display shown 6 or 12. This means that the unit is in the mode select menu.
8. The down arrow will then select the 6-position and the up arrow will select the 12-position. Press the up arrow button and make sure the display shows 12.
9. Hold down both arrow buttons until the display shows a different number (~3 s)
10. The unit is now able to operate a 12-position wheel

6.3. Error Codes & Troubleshooting

The following table describes some typical problems that may be encountered while using the FW102C or FW212C and possible solutions to these problems.

Problem	Solution
Unit does not turn on when switching the power switch to the ON position.	<ol style="list-style-type: none"> 1. Make sure the AC line cord is fully inserted into the AC input receptacle and plugged into an outlet providing 100 to 240 VAC.
I can't connect to the FW102C/FW212C over the USB port.	<ol style="list-style-type: none"> 1. Make sure the unit is turned on prior to connecting the USB. 2. Power off unit, remove AC cord, remove the USB cable, reattach AC cord, power on unit and reattach the USB cable. 3. Make sure USB drivers are installed.
Error Code "E#"	<ol style="list-style-type: none"> 1. Make sure the filter wheel is installed correctly, that the housing is seated correctly, and the thumbscrew is secure. 2. Remove the housing cover and filter wheel use compressed air to clear any dust or debris from the inside of the housing and green circuit board. If dust or debris blocks the sensors, this will result in erroneous filter wheel position movements or may cause the unit to seize. 3. Remove and inspect the blunt crenulated patterns cut into the inner rim of the wheel (opposite side of engraving). If one or more are bent or broken off, the sensors will be unable to read the correct position and the wheel will need to be replaced.

Chapter 7 Specifications

7.1. Performance

Parameter	Min	Typical	Max
Access Time (Adjacent Locations)			
FW102C, FW102CNEB	-	<1 s	-
FW212C, FW212CNEB	-	<0.5 s	-
Access Time (Other Locations)			
FW102C, FW102CNEB	-	2.5 s	-
FW212C, FW212CNEB	-	2.5 s	-
Accuracy / Repeatability	-	±2°	-
Expected Cycles	1.5 x 10 ⁶	-	-

7.2. Electrical

Parameter	Min	Typical	Max
BNC Input Trigger			
Max Rate	-	-	0.5 pulses/sec
Minimum Pulse Width	1.0 ms	-	-
BNC Input Trigger¹			
Input High	3.3 V	4.5 V	5.3 V
Input Low	0.3 V	0.0 V	1.0 V
BNC Output Trigger			
Output Pulse Width	9.0 ms	10.0 ms	11.0 ms
Output High²	2.5 V (1 KΩ)	3.3 V (1.95 KΩ)	5.0 V (Hi Z)
Output Low²	0.0 V	0.0 V	1.0 V
Power (DC Input, 1 A)	11.75 VDC	12 VDC	12.25 VDC
Operating Temperature	0 °C	-	60 °C

¹ The BNC input trigger is an active low input. The input has an internal 1 KΩ input resistor. Grounding the center conductor of the jack will activate the trigger.

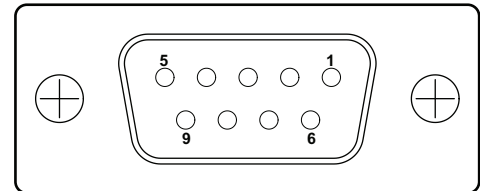
² When operating as an output, the unit output driver is configured in series with a 1 KΩ resistor.

7.3. Physical characteristics and Interface

Parameter	FW102C(NEB)	FW212C(NEB)
Trigger Jack	BNC Female	
Power Jack	Male 2.1 MM	
USB Connector	Mini B	
Mounting	(2) 1/4"-20, 8-32, (2) M6, M4, (2) SM1 Thread	
Max Planar Filter Width	0.25" (6.35 mm)	
Dimensions (L x W x H)	5.44" x 1.85" x 4.39" (138 mm x 47 mm x 112 mm)	
Weight (Without Power Supply)	1.65 lbs. (0.75 kg)	

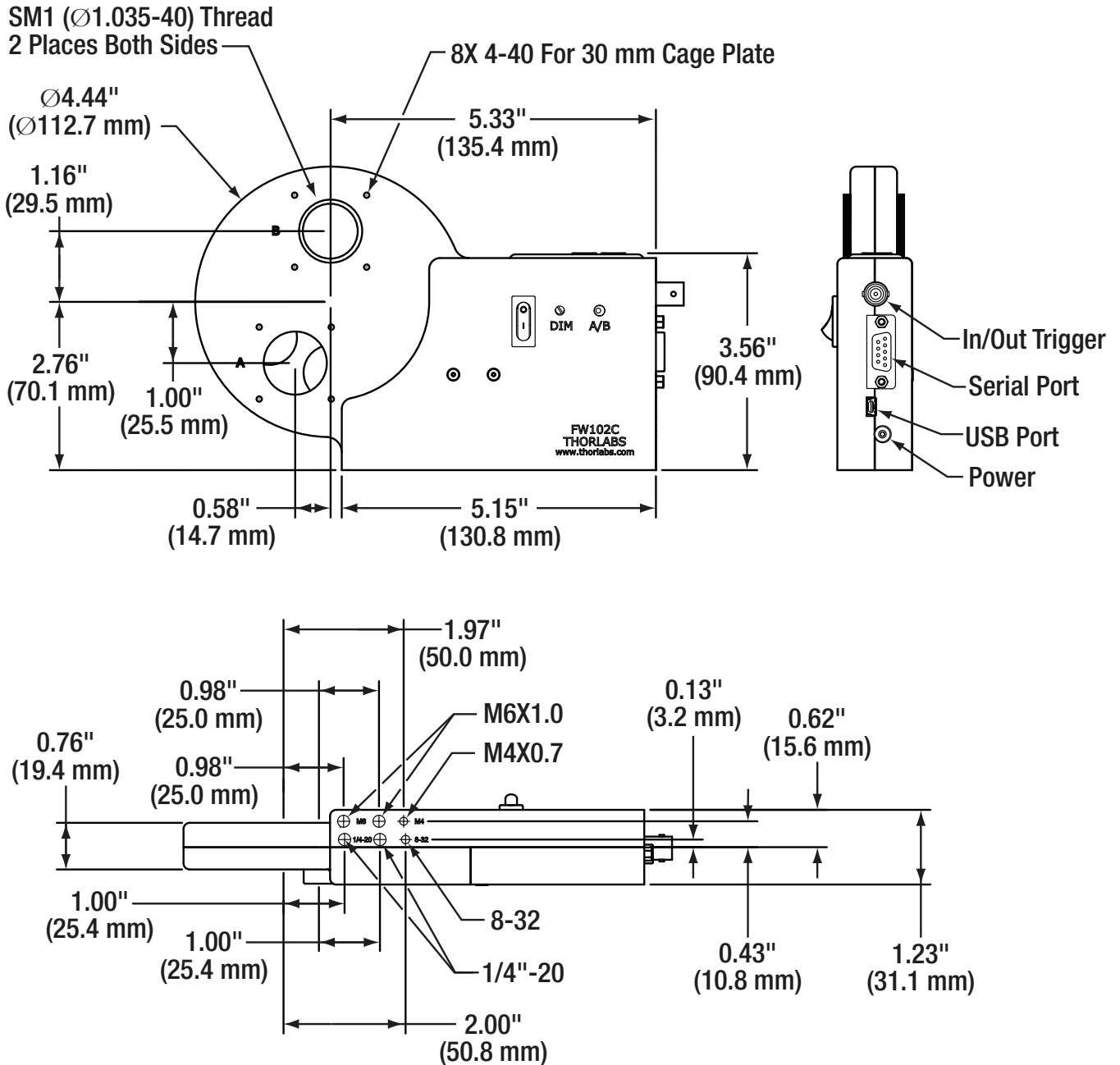
7.4. Pin Diagram

Pin	Connector	Pin	Connector
1	N.C.	6	N.C.
2	TR2 (From Housing)	7	Connected to Pin 8
3	RX2 (To Housing)	8	Connected to Pin 7
4	N.C.	9	N.C.
5	Signal Ground		

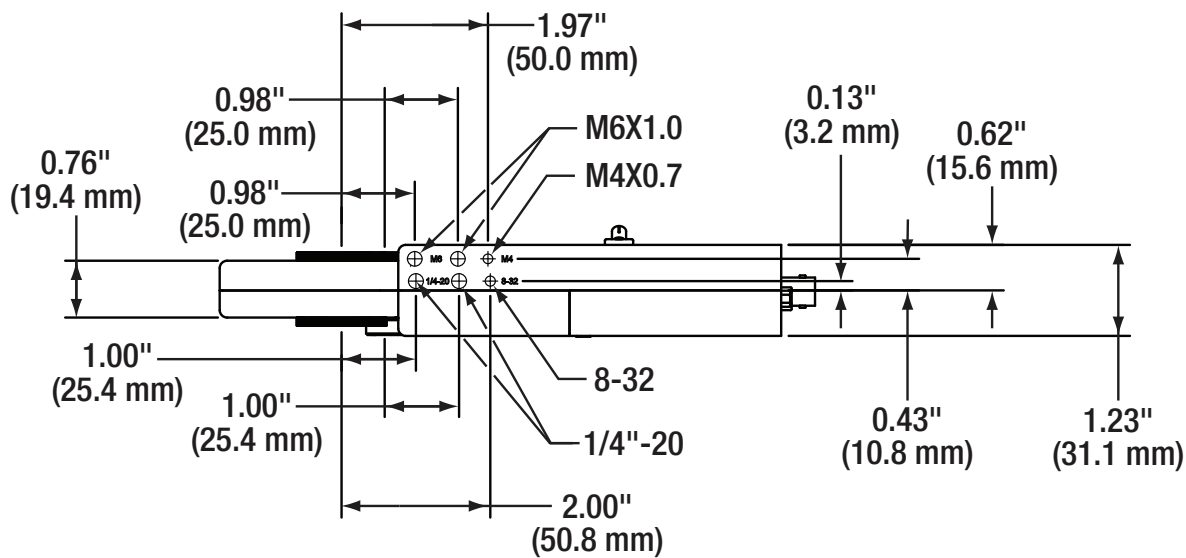
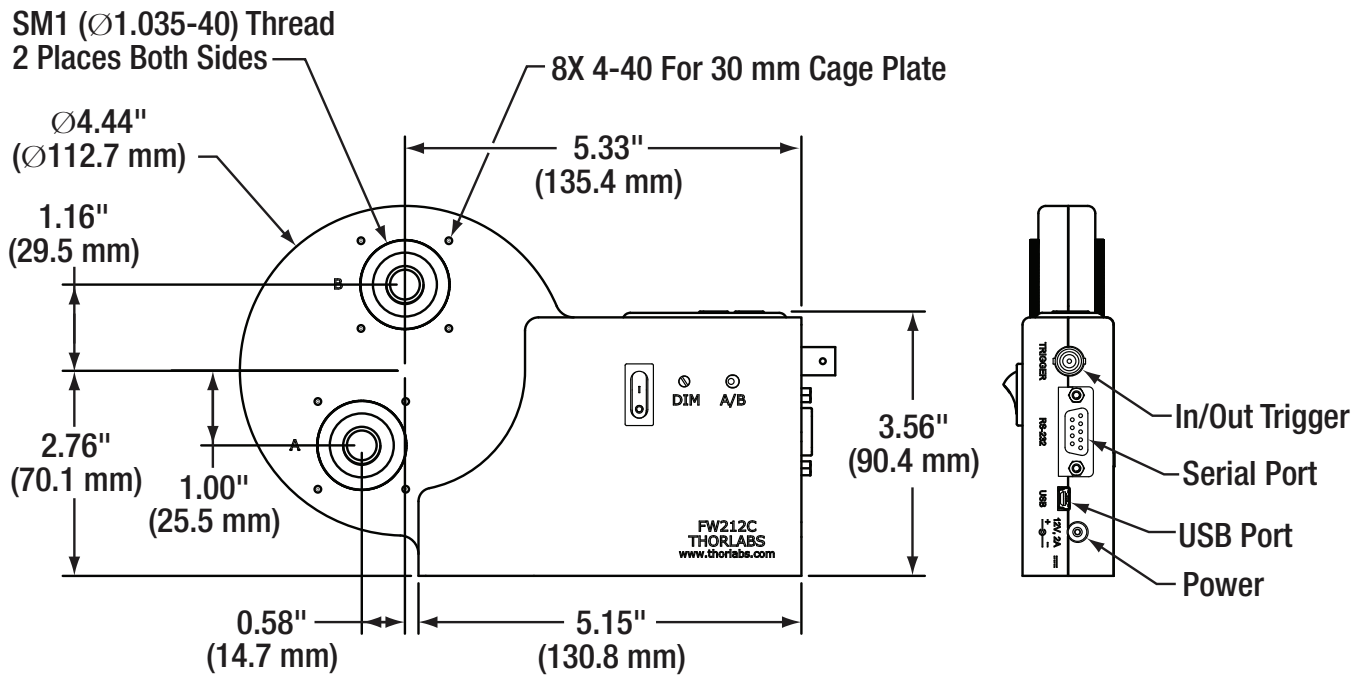


Chapter 8 Mechanical Drawings

8.1. FW102C, FW102CNEB



8.2. FW212C, FW212CNEB



Chapter 9 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated



Wheelie Bin Logo

As the WEEE directive applies to self-contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

9.1. Waste Treatment is Your Own Responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

9.2. Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

9.3. FCC Rules

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Chapter 10 Thorlabs Worldwide Contacts

USA, Canada, and South America

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Tel: +55-16-3413 7062
Fax: +55-16-3413 7064
www.thorlabs.com
Email: brasil@thorlabs.com

China

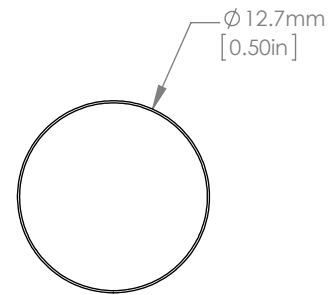
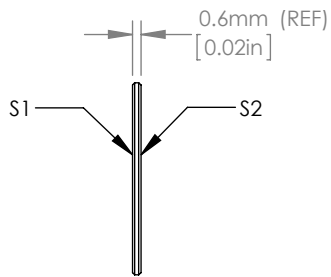
Thorlabs China
Room A101, No. 100
Lane 2891, South Qilianshan Road
Putuo District
Shanghai
China
Tel: +86 (0) 21-60561122
Fax: +86 (0)21-32513480
www.thorlabschina.cn
Email: chinasales@thorlabs.com



THORLABS
www.thorlabs.com

Allegato C3-A) Filtri Grigi UV (Assorbenti)

Attachment C3-A) Grey UV Filters (Absorptive)



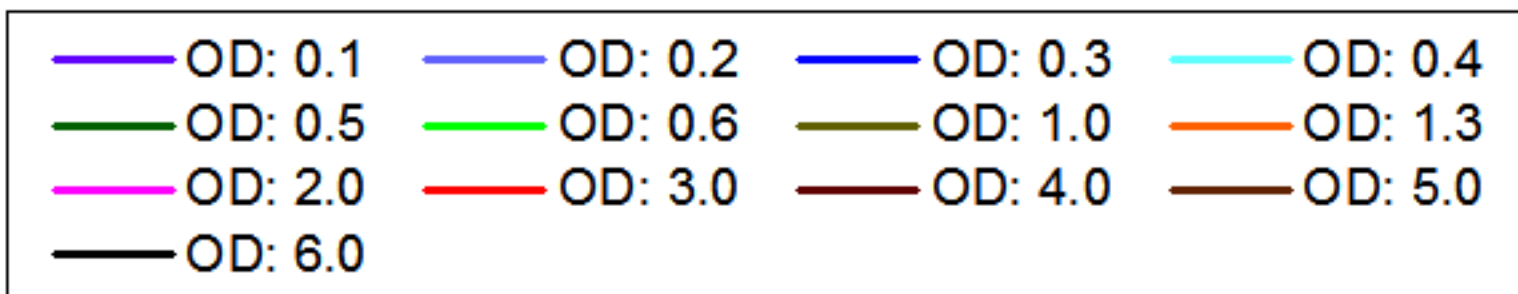
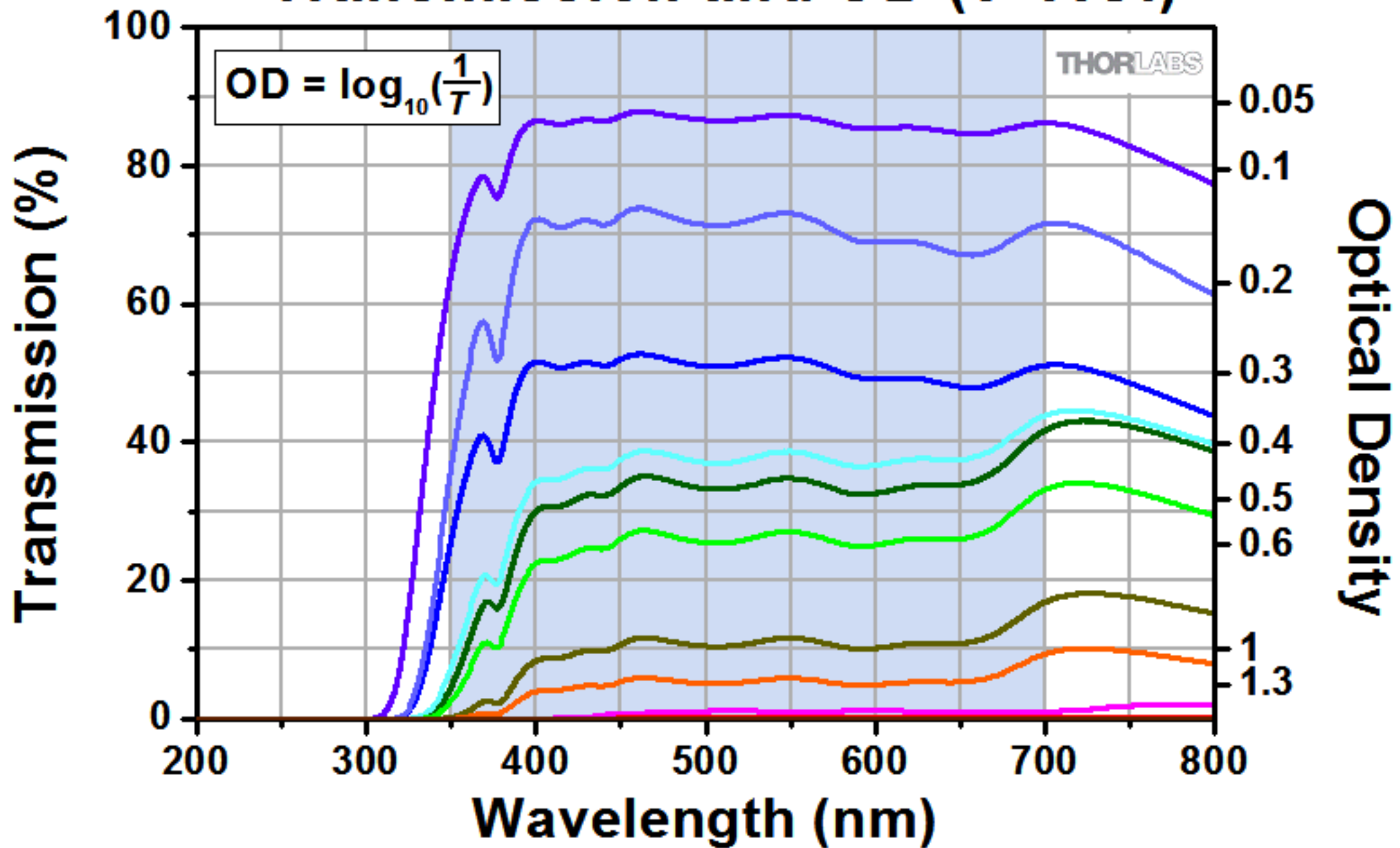
NOTES/SPECIFICATIONS:

1. OPTICAL DENSITY (PRIOR TO COATING): 0.1 ± 0.005 AT 633nm
2. MATERIAL: NG11 SCHOTT GLASS
3. CLEAR APERTURE: >90% OF DIAMETER
4. SURFACE QUALITY: 40-20 SCRATCH-DIG
5. SURFACE FLATNESS: $\lambda/4$ AT 633nm
6. PARALLELISM: 3 arcmin
7. DIMENSIONAL TOLERANCE: +0.00/-0.25mm
8. COATING (S1) & (S2): BBAR 350-700nm, Ravg: <0.5%
AOI: 0 deg

FOR INFORMATION ONLY
NOT FOR MANUFACTURING PURPOSES

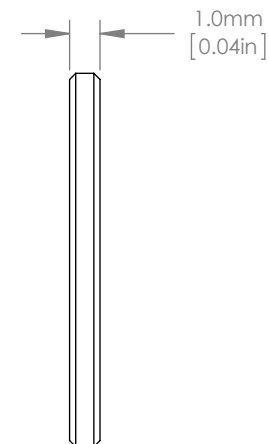
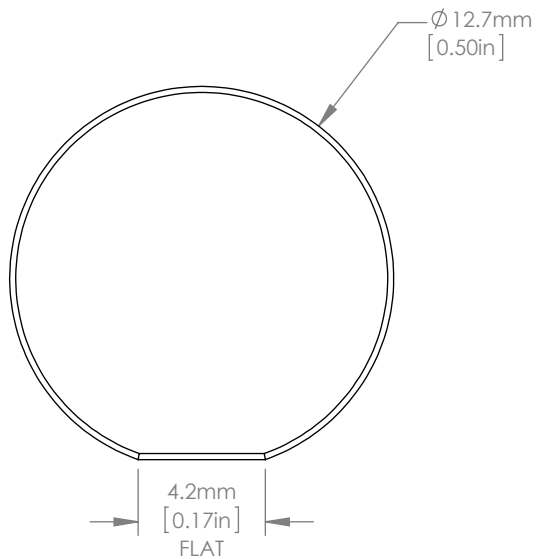
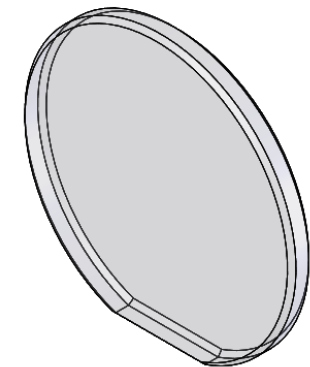
DRAWING PROJECTION			THORLABS www.thorlabs.com	
	NAME	DATE		
DRAWN	EMT	18/JUN/12	350-700nm BBAR COATED NG11 ABSORPTIVE NEUTRAL DENSITY FILTER	
APPROVAL	WD	25/JUL/12	MATERIAL	REV
COPYRIGHT © 2012 BY THORLABS VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS			NG11 SCHOTT GLASS	B
			ITEM #	APPROX WEIGHT
			NE501B-A	0.0002 kg

Transmission and OD (0° AOI)



Allegato C3-B) Filtri Grigi UV (Riflettenti)

Attachment C3-B) Grey UV Filters (Reflective)



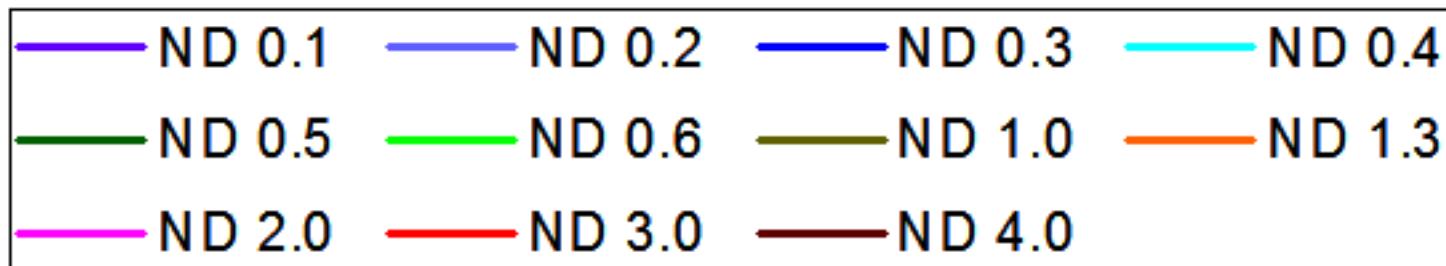
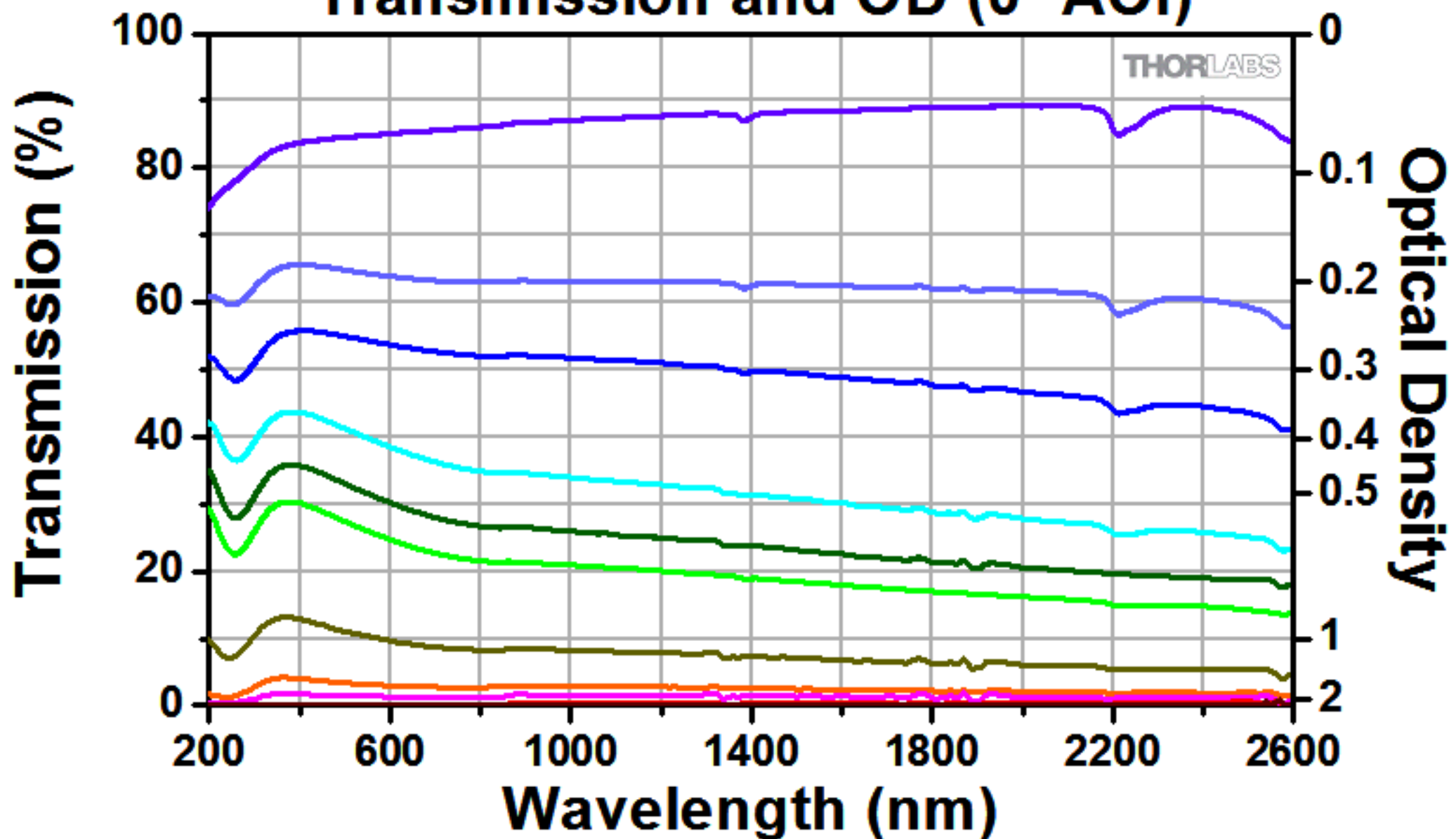
NOTES/SPECIFICATIONS:

1. OPTICAL DENSITY: 0.1 @ 300nm
2. NOMINAL TRANSMISSION: 79% @300nm
3. DIAMETER TOLERANCE: +0.0/0.25mm
4. THICKNESS TOLERANCE: \pm 0.25mm
5. SURFACE ACCURACY: $<2\lambda$ AT 633nm
6. SURFACE QUALITY: 40-20 SCRATCH-DIG
7. CLEAR APERTURE: 90% O.D
8. PARALLELISM: <3 arcmin
9. OPTIMIZED: 200-400nm
10. USABLE: 200-1200nm

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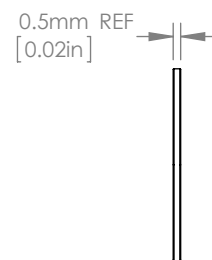
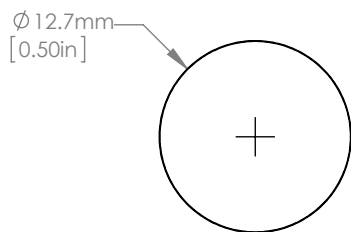
DRAWING PROJECTION			THORLABS www.thorlabs.com	
	NAME	DATE	ϕ 12.7mm REFLECTIVE NDUV FILTER, OD=0.1	
DRAWN	GG	08/MAR/12	MATERIAL	REV
APPROVAL	DD	08/MAR/12	UV GRADE FUSED SILICA	A
COPYRIGHT © 2012 BY THORLABS <small>VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS</small>			ITEM #	APPROX WEIGHT
			NDUV501B	1.3 g

Reflective UV Fused Silica ND Filters: Transmission and OD (0° AOI)



Allegato C4) Filtri Grigi IR

Attachment C4) Grey IR Filters



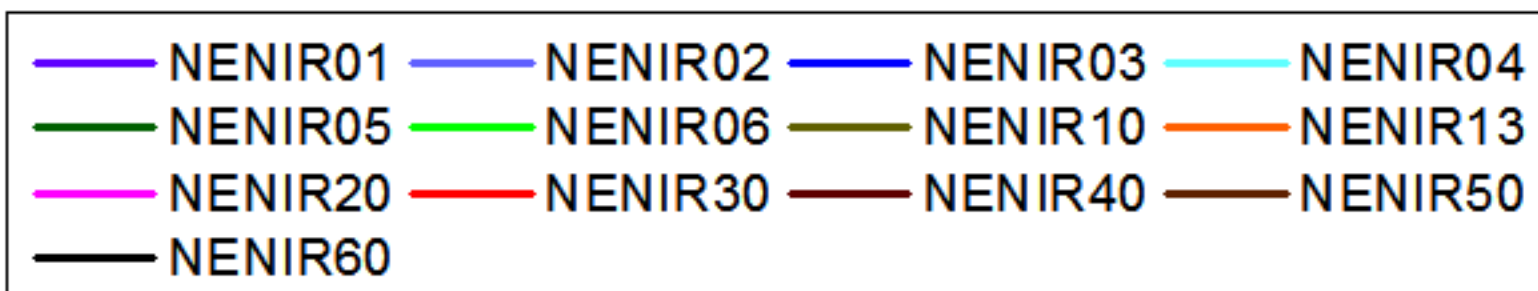
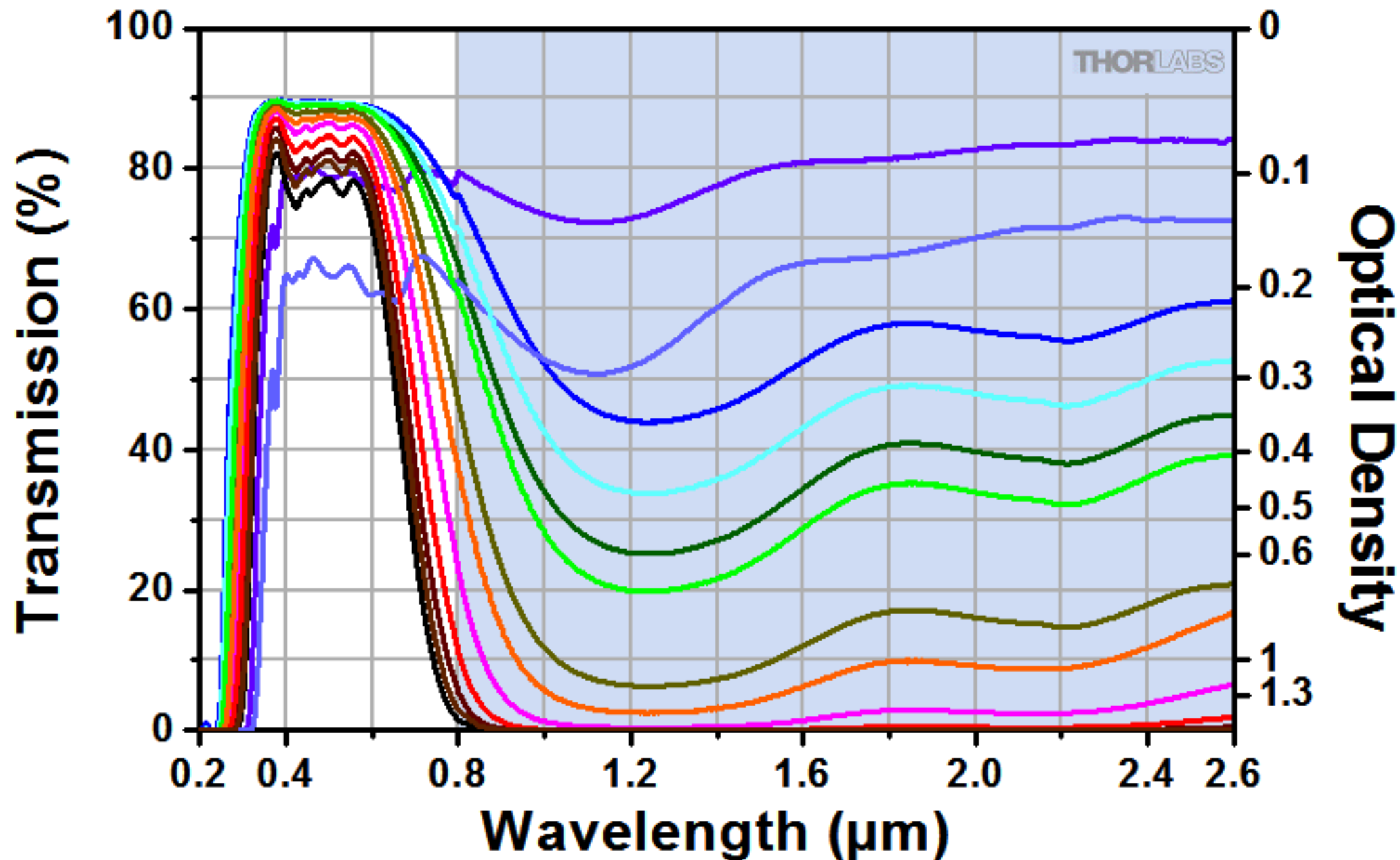
NOTES/SPECIFICATIONS

1. OPTICAL DENSITY:
0.09 AT 1550nm
0.14 AT 1064nm (REF)
2. CLEAR APERTURE: 90% OF DIAMETER
3. DESIGN WAVELENGTH: 1550nm
4. SURFACE FLATNESS: $\lambda/4$ AT 633nm
5. DIAMETER TOLERANCE +0.00 / -0.25mm
6. OPTICAL DENSITY TOLERANCES: <5% AT 1550nm
7. SURFACE QUALITY: 40-20 SCRATCH-DIG
8. PARALLELISM: <10 arcsec
9. THICKNESS DETERMINED BY THE OPTICAL DENSITY OF THE PARTICULAR LOT OF MATERIAL

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DRAWING PROJECTION			THORLABS www.thorlabs.com Ø12.7mm NIR ABSORPTIVE FILTER, OPTICAL DENSITY: 0.1	
NAME	DATE			
DRAWN	EMT	14/SEP/12	MATERIAL NG11 (SCHOTT)	
APPROVAL	MG	08/OCT/12		
COPYRIGHT © 2012 BY THORLABS VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS			ITEM #	APPROX WEIGHT
			NENIR501B	0.10 g

NENIR Filters: Transmission and OD



Allegato C5) Fibra Intermedia UV

Attachment C5) Intermediate UV Fiber

CeramOptec®

Innovative Fiber Optics...Every Step of the Way™

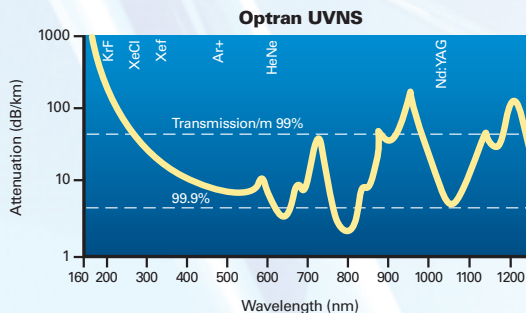
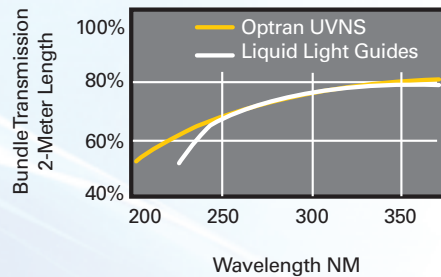
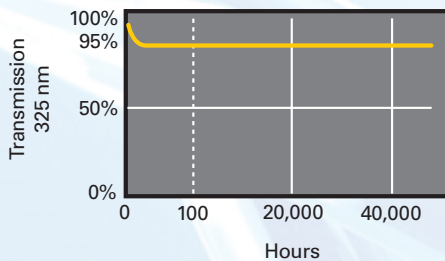
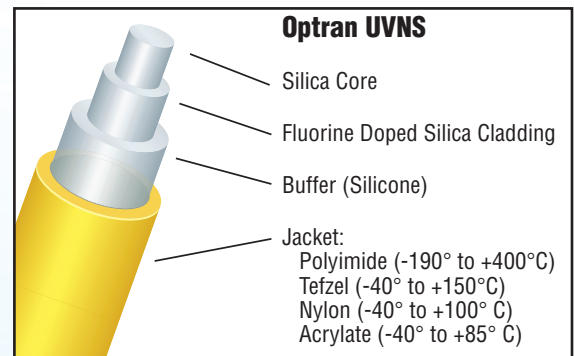
Leading the Way in Long-Term Performance

Setting new standards through breakthrough research and development is at the heart of our business. As the manufacturer of the world's first UV Non-Solarizing (UVNS) optical fiber, CeramOptec continues to find ways to break down the barriers for simplifying UV spectroscopy and sensing applications.

For long-term performance, Optran UVNS fibers and PowerLightGuide bundles set the standard. Tested for well over 40,000 continuous, unfiltered hours, our Optran UVNS fibers exhibit level, steady transmission at 95% of the original input!

Setting the Standards in Deep UV

Optran UVNS all silica optical fibers offer exceptional throughput in wavelengths ranging from 160 to 1200 nm—without solarization. When used in our PowerLightGuide™ Fused-End Bundles, our Optran UVNS fibers allow typical bundle transmission to be 50% higher than any other manufacturer of fused silica UV fiber products. CeramOptec's PowerLightGuide bundles are fused at the ends to eliminate inter-fiber spaces—while maintaining the fibers' NA. Please see our PowerLightGuide Bundle data sheet for more information about our non-solarizing bundles—a solid solution to UV Spectroscopy and Liquid Light Guides.



Applications

■ Industrial/Scientific

Replacement for UV Liquid Light Guides
Spectroscopy
Sensors
UV photolithography
Laser welding/soldering/marketing
Laser delivery
Nuclear plasma diagnostics
Analytical instruments

Laser diode pigtailling
Pyrometry
Semiconductor capital equipment
Thomson scattering
UV illumination and monitoring
UV Raman spectroscopy
UV curing

■ Medical

Medical diagnostics
Laser delivery

Photodynamic therapy
Medical treatments such as UV psoriasis treatment

Features

Broad UV/VIS/NIR spectral range: 160 – 1200 nm
High laser damage resistance
Broad temperature range
High core to clad ratio
Large core diameters to 1700 μm
Biocompatible materials

Radiation resistance: 10^9 rad. total
Sterilizable by ETO and other methods
Manufactured at GMP and ISO 9001 compliant facility
Specialty coatings available for high temperatures, high vacuum, and harsh chemicals
All dielectric, non-magnetic construction

Properties

Step index profile
Pure silica core
Available NAs:
Low NA – 0.12 ± 0.02
Standard NA – 0.22 ± 0.02
Optran Plus™ $0.28 - 0.28 \pm 0.02$
Optran Plus™ $0.30 - 0.30 \pm 0.02$
Standard proof test: 70 kpsi
Core/clad ratios available: 1:1.06, 1:1.1, 1:1.15, 1:1.2, 1:1.25, 1:1.4

Minimum bend radius:
100 x clad radius (momentary)
300 x clad radius (long term)
Laser damage threshold:
XeCl 18.0 mJ/mm² (200ns pulse) at 308 nm
XeCl 8.0 mJ/mm² (20ns pulse) at 308 nm
Nd:YAG 5.4 J/mm² (1 ms pulse) at 1060 nm
Nd:YAG 1.3 kW/mm² (CW) at 1060 nm

Optran UVNS (0.22 NA) Standard Core Sizes (0.28 and 0.30 NA Also Available)

50	200	400	600	1000	1500
100	300	500	800	1250	1700

Notes:

Custom sizes are available upon request.

NA is measured at the 95% intensity angle.

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Innovative Fiber Optics...Every Step of the Way

CeramOptec was founded in 1986 and today is a global leader in the production of stock and custom silica / silica, plastic-clad silica, and hard polymer-clad silica optical fibers; fused capillary tubing; DPSS lasers; diode modules; and low loss bundles and assemblies for UV, VIS, and IR transmission, medical laser delivery, sensors, plasma fusion, and spectroscopy.

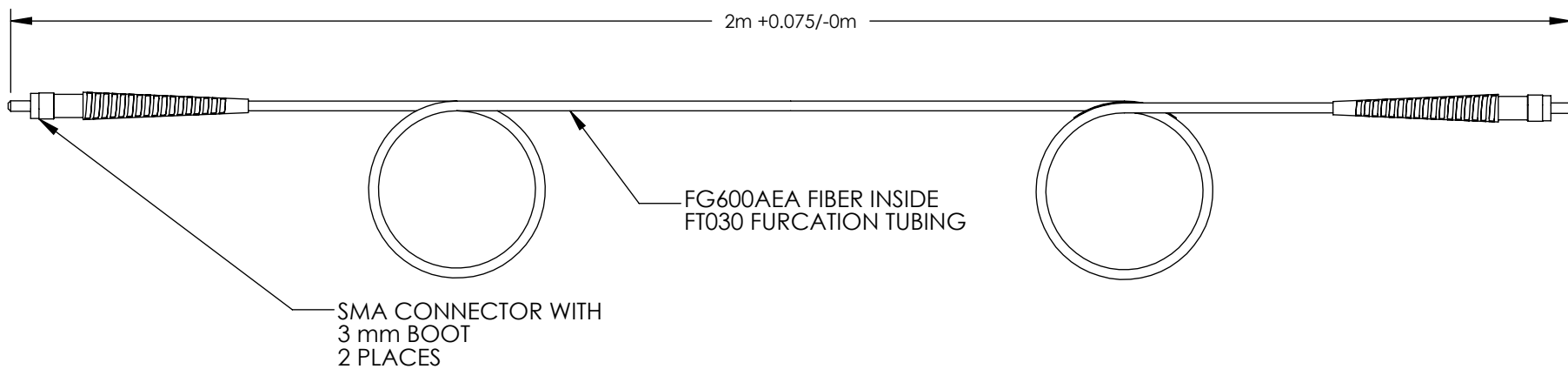
With several facilities worldwide, we are able to provide our customers with local, prompt, and reliable service and products. By maintaining complete control over the entire manufacturing process—from preform manufacturing to finished fiber product—we are able to provide the highest quality control, custom solutions, and competitive pricing to our customers.

Please visit <http://www.ceramoptec.com> for more information.

CeramOptec is a subsidiary of biolitec™ AG.

Please visit <http://www.biolitec.com> for more information.

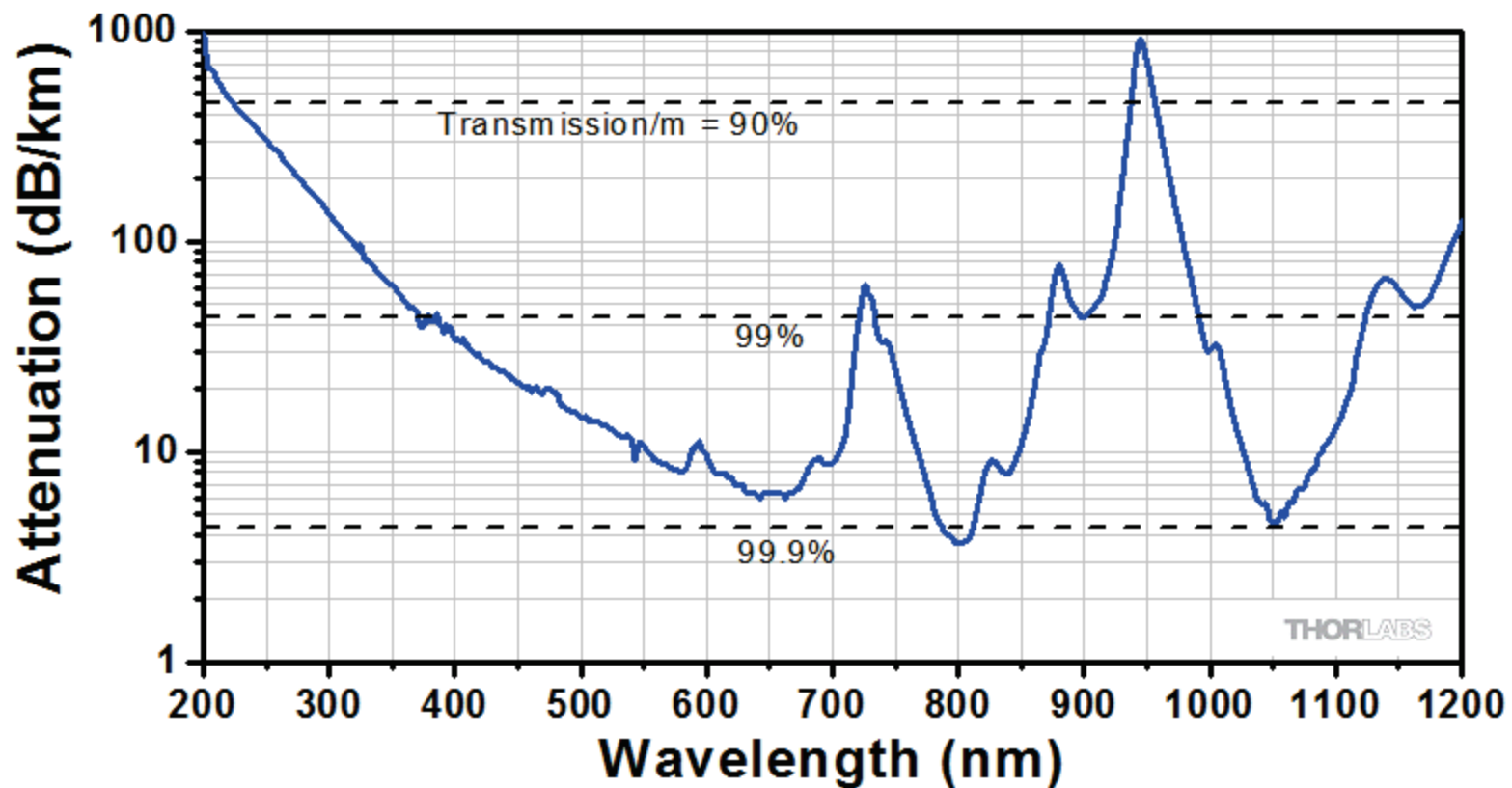
FIBER SPECIFICATIONS					
ITEM #	CORE DIAMETER	CLADDING DIAMETER	COATING DIAMETER	NA	WAVELENGTH RANGE
FG600AEA	600 +/- 12 μ m	660 +/- 6 μ m	750 +/- 20 μ m	0.22	180 to 1200 nm



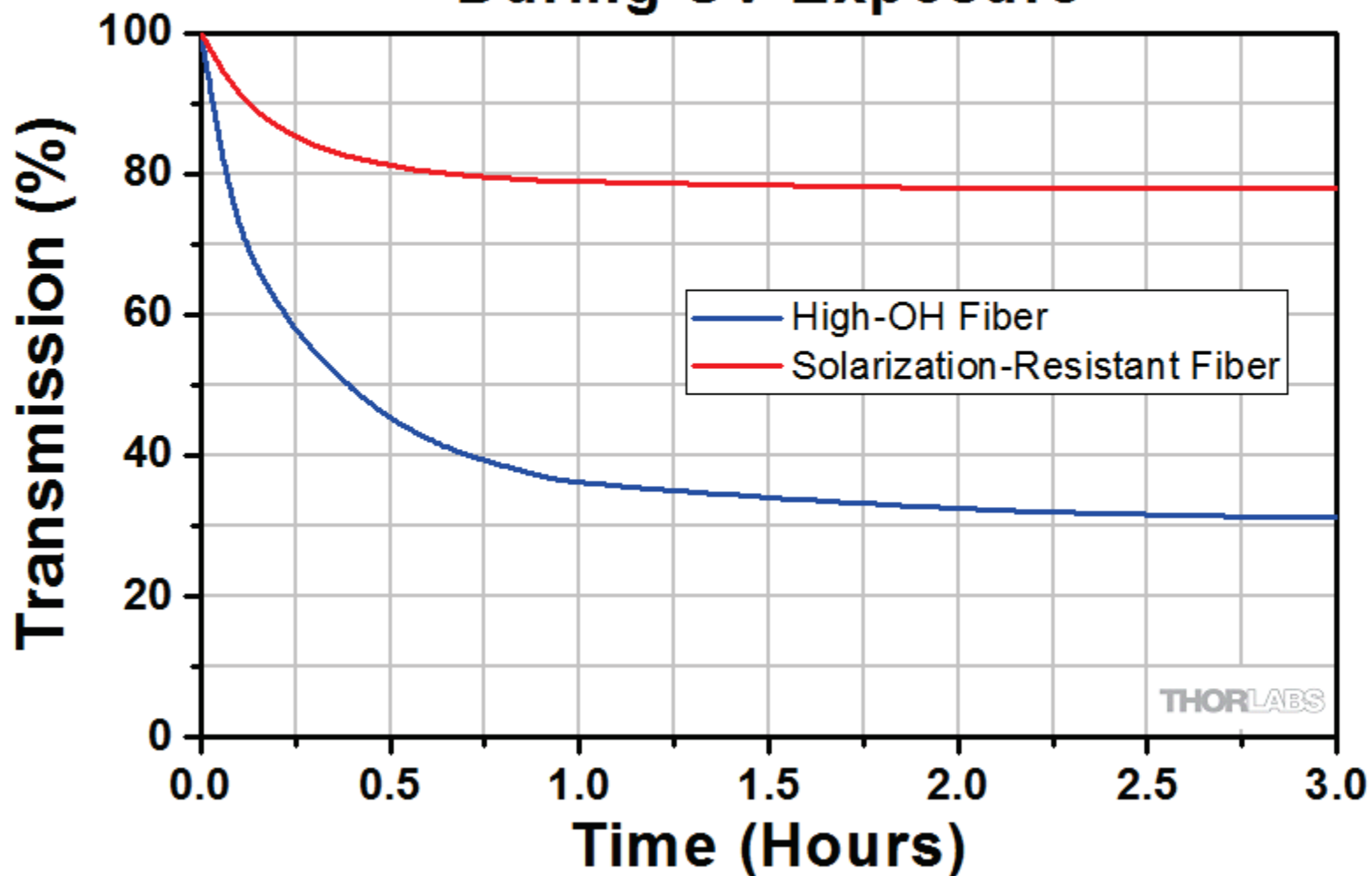
FOR INFORMATION ONLY
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DRAWING PROJECTION			THORLABS www.thorlabs.com	
NAME	DATE	2 m, 600 μ m 0.22 NA SMA TO SMA CABLE		
DRAWN	IR	01/JUN/15	MATERIAL	
APPROVAL	BAG	04/JUN/15	N/A	
COPYRIGHT © 2015 BY THORLABS			ITEM #	APPROX WEIGHT
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS			M114L02	0.02 kg
			REV	A

Solarization-Resistant Multimode Fiber Attenuation



Fiber Transmission at 215 nm During UV Exposure

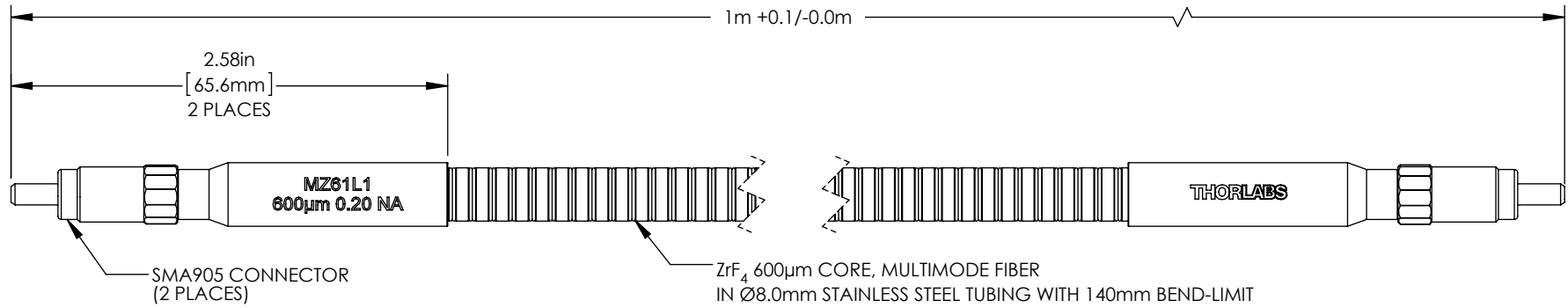


Allegato C6) Fibra Intermedia IR

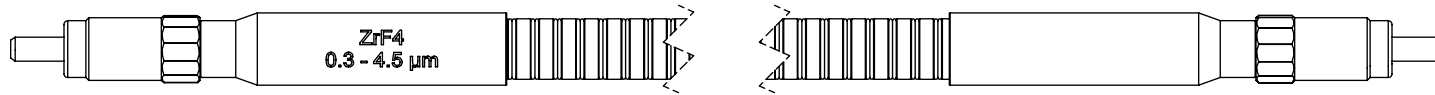
Attachment C6) Intermediate IR Fiber

ZrF ₄ FIBER SPECIFICATIONS*						
OPERATING WAVELENGTH	ATTENUATION (2.0μm TO 3.6μm)	NUMERICAL APERTURE	CORE DIAMETER	CLADDING DIAMETER	SHORT TERM BEND RADIUS	LONG TERM BEND RADIUS
285 nm - 4.5 μm	≤ 0.25 dB/m	0.20 ± 0.02 @ 2.0μm	600 ± 20μm	690 ± 20μm	≥75 mm	≥ 160 mm

*BASED ON UNTERMINATED FIBER DATA



BACK VIEW OF STAINLESS STEEL SLEEVES

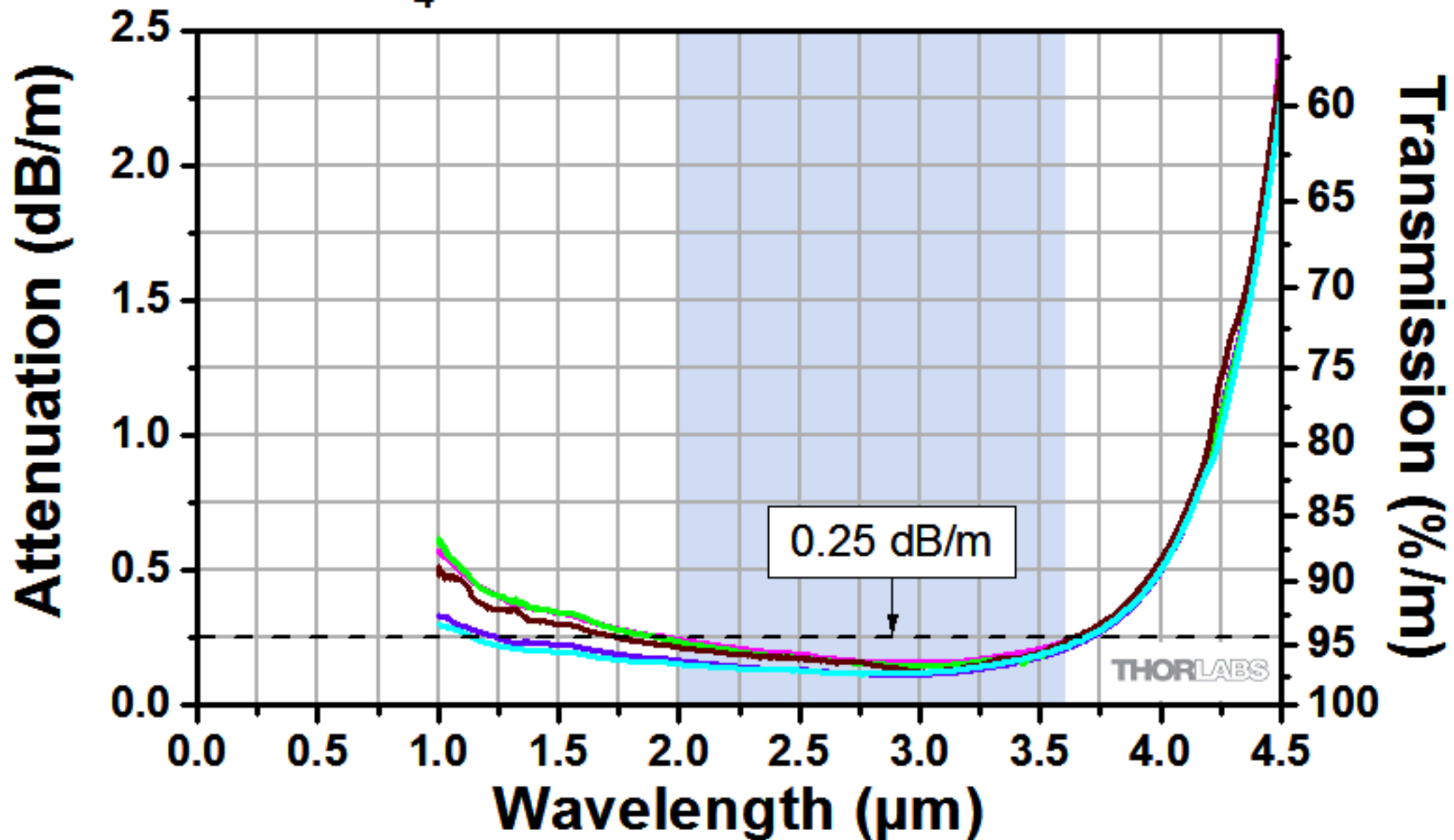


INCLUDED BUT NOT SHOWN:
2 PROTECTIVE METAL DUST CAPS

FOR INFORMATION ONLY
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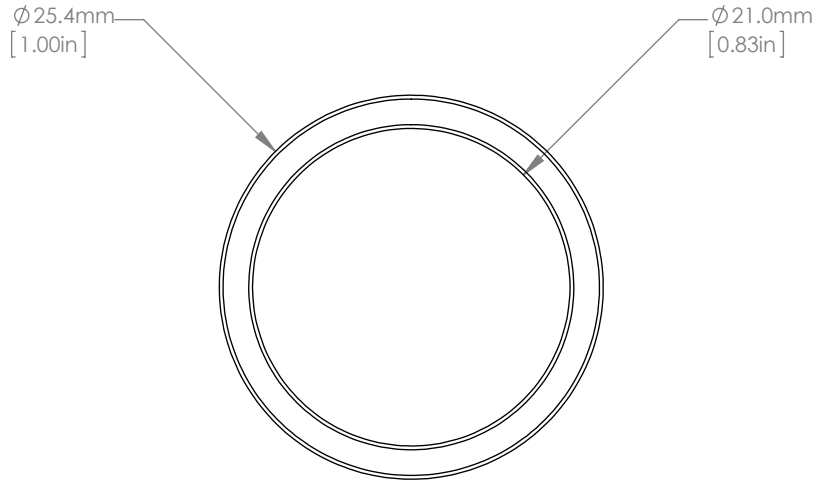
DRAWING PROJECTION			THORLABS www.thorlabs.com	
NAME	DATE	MM ZrF ₄ IR PATCH CABLE, 1m, 285nm-4.5μm 600μm CORE, 0.20 NA, SMA TO SMA CABLE		
DRAWN	CAL	29/JAN/15	MATERIAL	REV B
APPROVAL	BAG	22/APR/15	N/A	
COPYRIGHT © 2015 BY THORLABS			ITEM #	APPROX WEIGHT
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS			MZ61L1	135g

Ø600 μm ZrF_4 Attenuation (5 Independent Runs)

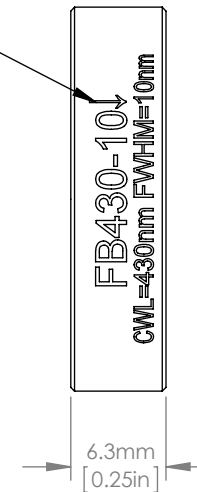


Allegato C7) Filtri Passa-banda UV

Attachment C7) UV Band-pass Filters



ENGRAVED ARROW INDICATES
SUGGESTED DIRECTION
OF LIGHT TRANSMISSION



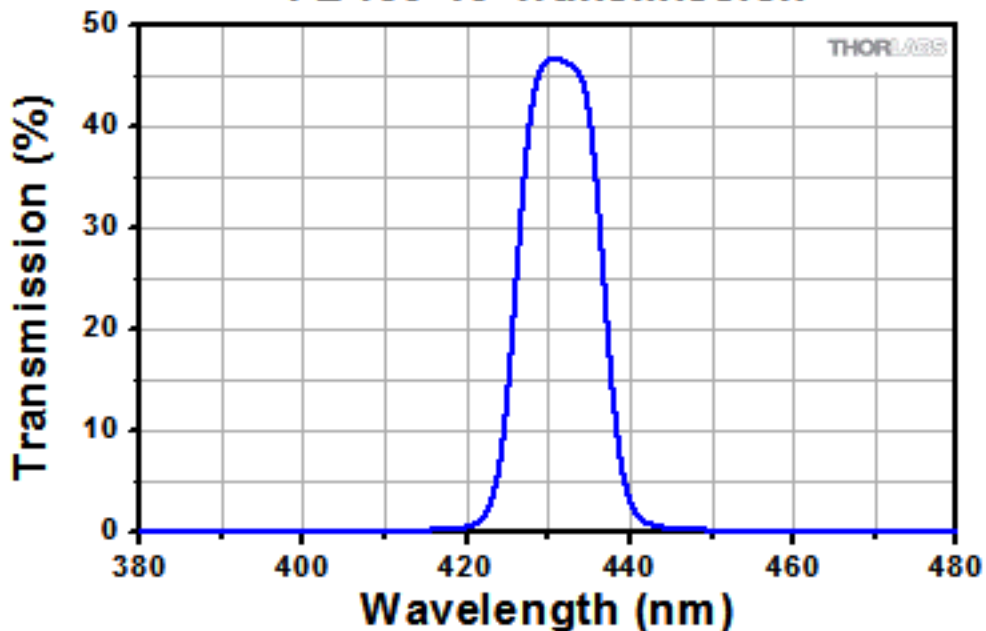
NOTES/SPECIFICATIONS:

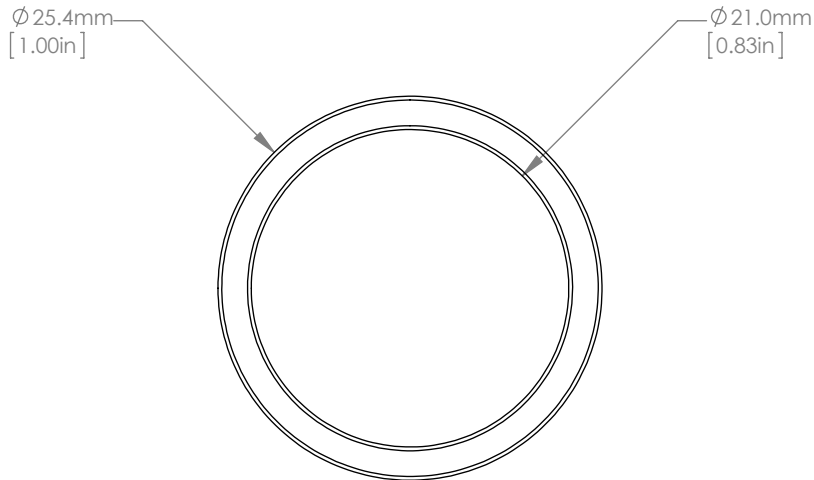
1. CENTER WAVELENGTH (CWL): 430nm \pm 2nm
2. FULL WIDTH HALF MAX(FWHM): 10nm \pm 2nm (NOMINAL)
3. TRANSMISSION MINIMUM: 45%
4. BLOCKING: 200nm-3000nm > OD4
5. SURFACE/COATING QUALITY: 80-50 SCRATCH-DIG
6. OPERATING TEMPERATURE: -50°C TO +80°C
7. OPTIMUM OPERATING TEMPERATURE: 23°C
8. EDGE TREATMENT: MOUNTED IN BLACK ANODIZED ALUMINUM RING

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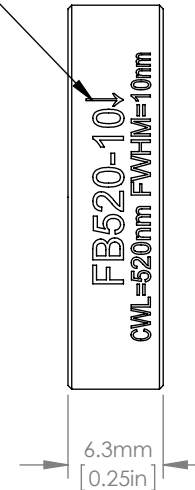
DRAWING PROJECTION			THORLABS www.thorlabs.com Ø 25.4mm BANDPASS FILTER CWL=430nm, FWHM=10nm	
NAME	DATE			
DRAWN	CR	25/MAY/12	MATERIAL SCHOTT BOROFLOAT & SODA LIME	
APPROVAL	DD	16/AUG/12		
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			FB430-10	27 g

FB430-10 Transmission





ENGRAVED ARROW INDICATES
SUGGESTED DIRECTION
OF LIGHT TRANSMISSION



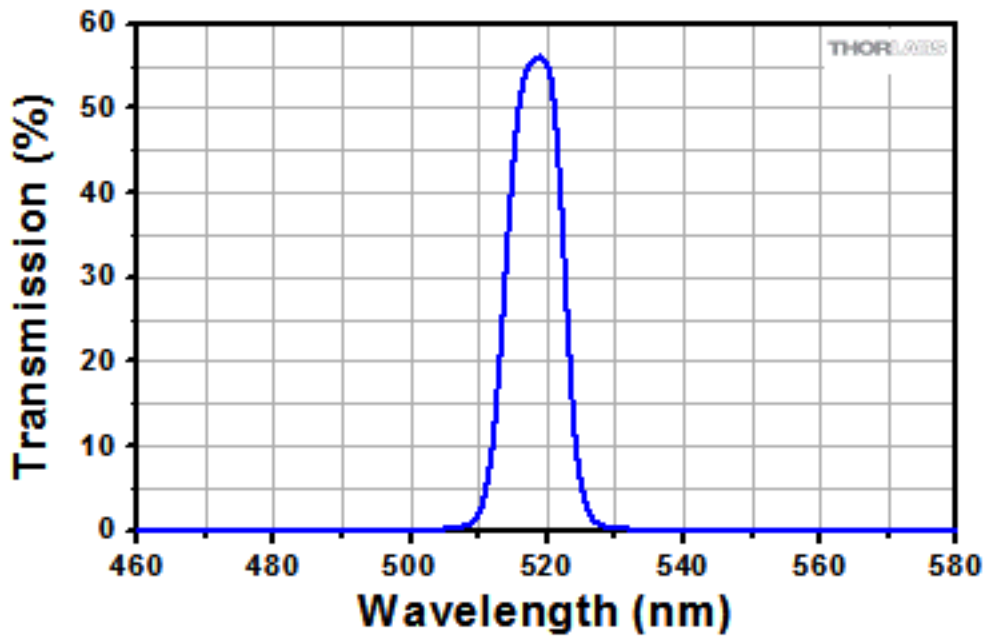
NOTES/SPECIFICATIONS:

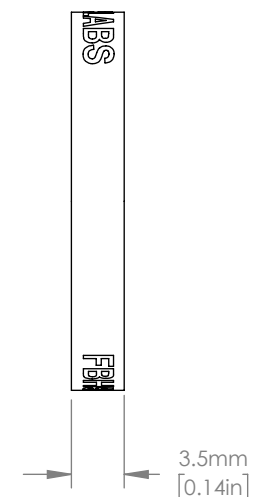
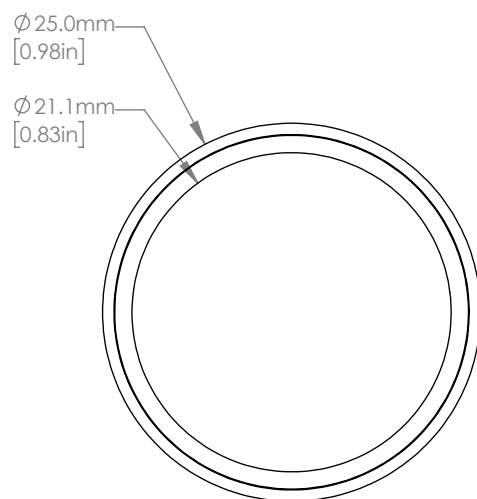
1. CENTER WAVELENGTH (CWL): 520nm \pm 2nm
2. FULL WIDTH HALF MAX(FWHM): 10nm \pm 2nm (NOMINAL)
3. TRANSMISSION MINIMUM: 50%
4. BLOCKING: 200nm-3000nm > OD4
5. SURFACE/COATING QUALITY: 80-50 SCRATCH-DIG
6. OPERATING TEMPERATURE: -50°C TO +80°C
7. OPTIMUM OPERATING TEMPERATURE: 23°C
8. EDGE TREATMENT: MOUNTED IN BLACK ANODIZED ALUMINUM RING

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DRAWING PROJECTION			THORLABS www.thorlabs.com $\phi 25.4\text{mm}$ BANDPASS FILTER CWL=520nm, FWHM=10nm	
NAME	DATE			
DRAWN	CR	25/MAY/12	MATERIAL SCHOTT BOROFLOAT & SODA LIME	
APPROVAL	DD	16/AUG/12		
COPYRIGHT © 2012 BY THORLABS VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS			ITEM #	APPROX WEIGHT
			FB520-10	27 g

FB520-10 Transmission





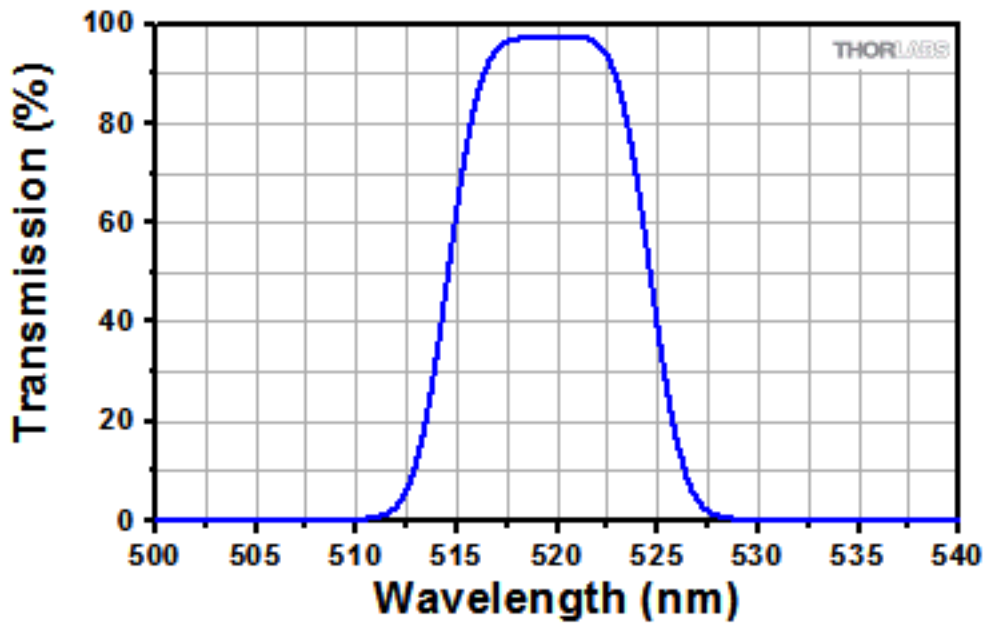
NOTES/SPECIFICATIONS:

1. CLEAR APERTURE: $\phi 21.1\text{mm}$
2. TRANSMITTED WAVEFRONT ERROR: $\lambda/4$ AT 520nm OVER CLEAR APERTURE
3. SURFACE QUALITY: 60-40 SCRATCH-DIG
4. COATING: BANDPASS FILTER, HARDCOATED
 TRANSMISSION: >90% AT 520nm
 FWHM: 10nm
 BLOCKING: >OD5 200-500nm AND 540-1200nm

FOR INFORMATION ONLY
 NOT FOR MANUFACTURING PURPOSES

DRAWING PROJECTION			 www.thorlabs.com HARDCOATED LASER LINE FILTER CWL: 520nm FWHM: 10nm	
NAME	DATE			
DRAWN	MG	24/MAY/16	MATERIAL ALUMINUM, UVFS	
APPROVAL	PM	26/MAY/16		
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			FBH520-10	3 g

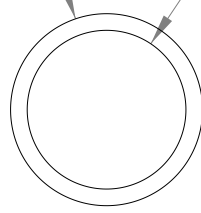
FBH520-10 Transmission



F9J "	89G7 F-DHC B.	B5A 9#85H9.

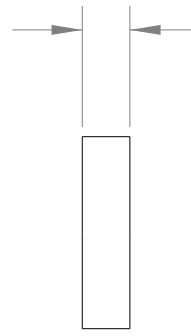


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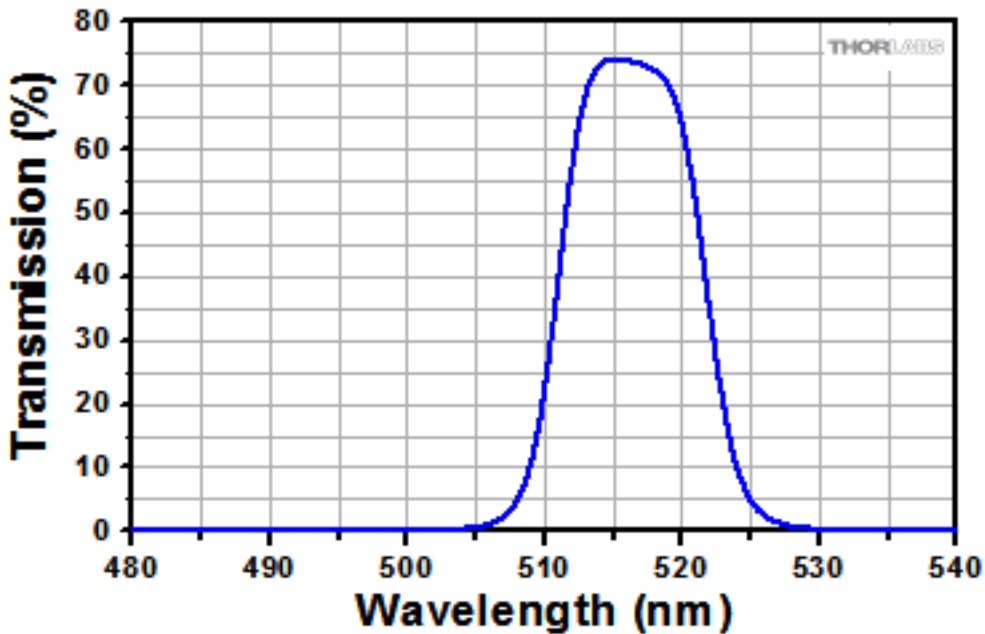


@5G9F @B9. 5f[cb
 7 9BH9F K 5J 9@B; Hk f7 K @)%(")ba '-&
 :l @@K -Bk '<5@ 'A 5L f1K <A t %\$ba '-&
 HF5BGA -GGC B 'A -B. *)i
 6@ 7? -B; . '21' C 8('A -B" I J!%\$) \$ba
 C DHA I A 'C D9F5HB; 'H9A D9F5H F9.' & '7
 98; 9HF95HA 9BH'A C I BH98 'B '6@5 7? '5BC 8 #98 'F -B;
 98; 9A 5F? -B; . '7K @: K <A ' 'B 8-7 5H9GK 9'
 8 -F 97 HC B 'C: 'H 9 @ < HHF5BGA -GGC B
 C D9F5HB; 'H9A D9F5H F9.!) \$=rc Ž, \$=7
 G I: 57 9E I 5@HM, \$#) \$D9F 'A @ \$!%, ' \$

HC@F5B79G	B5A 9	85H9
I B@GGC H: 9FK @9 GD97 =98.	8F5K B	65; (#&- #&\$ \$*
8-A 9BGC BG5F9-B 'B7 <9G	9B; '5DDF"	HC (#&- #&\$ \$*
@B95F HC@F5B79G	A:; '5DDF"	HC (#&- #&\$ \$*
...HK C D@57 9897 -A 5@ ±\$"\$%\$	DFC DF-96FM5B8 7CB: -B9BH5@	
...H: F99D@57 9897 -A 5@ ±\$"\$%\$)	H: 9 -B: CFA 5HC B 7 C B H5 -B 98 -B H: 6	
5B: I @F. ±' \$f"	8F5K -B: '6H: 9GC @DFC D9FHMC:	
GI: 57 9: -B -G<." &A -7FC -B7 <9G	H: C F @5 6GZ -B7 "'5B MF9DFC 8I 7 HC B	
D5F5 @9@CA. "\$\$\$&	-B D5FHC F 5G5 K <C @K H: C I H	
: @5B 9CG "\$\$\$&	7C B7 9B HF -7 HM "\$\$\$&	
GF 5 = <HB 9CG "\$\$\$&	D9F D9B 8-7 I @5F HM "\$\$\$&	
7C B7 9B HF -7 HM "\$\$\$&	H: 9K F #9B 'D9FA -GGC B 'C:	
D9F D9B 8-7 I @5F HM "\$\$\$&	H: C F @5 6GZ -B7 "'6DFC <-6+98"	
H: F 95 8. 7 @5GG &: #		

Hk C F @5 6G 'B 7 "				DC '6C L' **
				B 9K HC B B >
H# @.		« %" @5G9F @B 9: -@HF		
A 5H9F 5@	G7 <C H I 6C FC: @C 5H/ 'GC 85 '@A 9	G #9	F 9J "	5 5
G7 5 @9%%		G< 99H% C: %		
8K; "'BC "	D5FH 'BC "	+ ' % !9\$% : @% (")!%\$		

FL514.5-10 Transmission

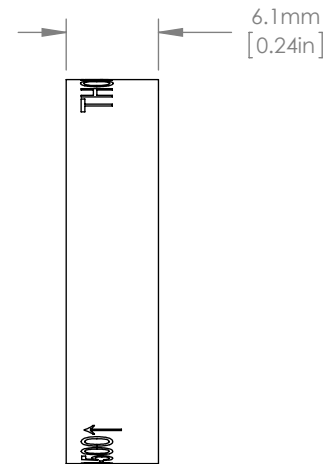
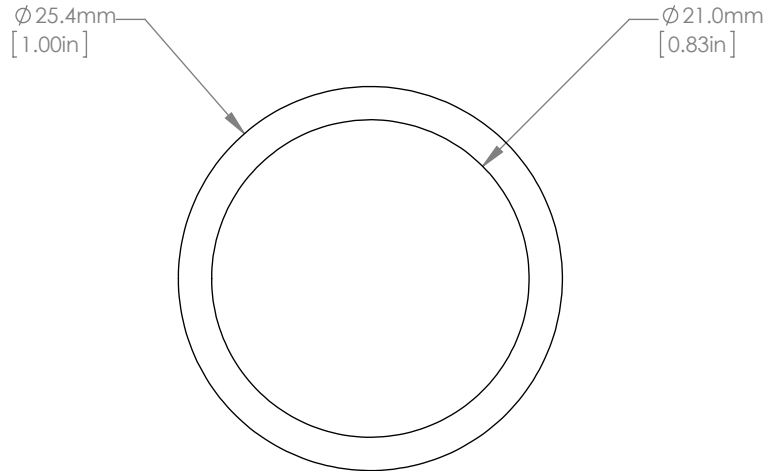


Allegato C8) Filtri Passa-banda IR

Attachment C8) IR Band-pass Filters

ARROW POINTS IN DIRECTION
OF FILTER TRANSMISSION

FB1750-500↑



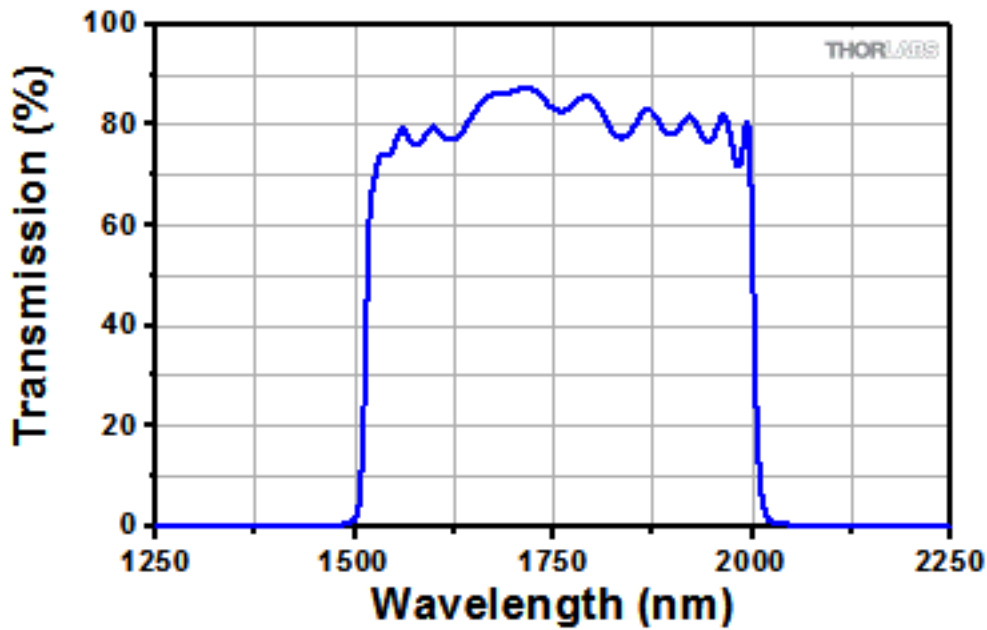
NOTES/SPECIFICATIONS:

1. CENTER WAVELENGTH (CWL): 1750nm
2. FULL WIDTH HALF MAXIMUM (FWHM): 500nm
3. TRANSMISSION MINIMUM: 70% AT CWL
4. OUT OF BAND TRANSMISSION: <0.1% FROM 0.200 μ m to 12 μ m
5. CLEAR APERTURE: 21.0mm
6. SURFACE QUALITY: 80-50 SCRATCH-DIG
7. OPERATING TEMPERATURE: -50° TO 80° C
8. EDGE TREATMENT: MOUNTED IN BLACK ANODIZED ALUMINUM RING
9. EDGE MARKINGS: CENTER WAVELENGTH-FULL WIDTH HALF MAX

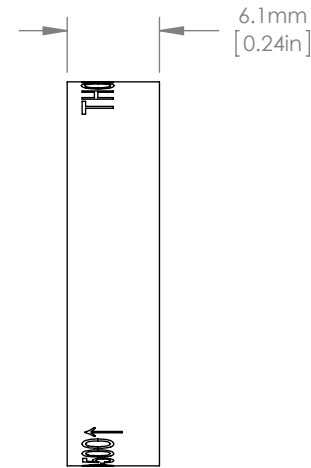
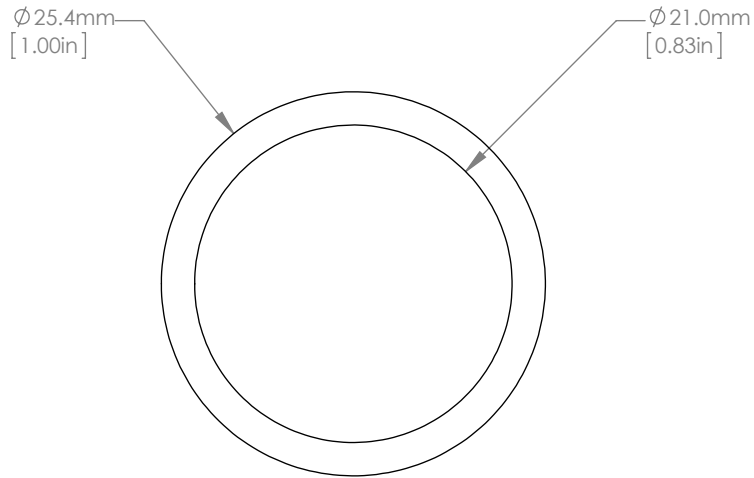
FOR INFORMATION ONLY
NOT FOR MANUFACTURING PURPOSES

DRAWING PROJECTION			THORLABS www.thorlabs.com BANDPASS FILTER, CWL=1750nm, FWHM = 500nm	
NAME	DATE			
DRAWN	GG	18/FEB/13	MATERIAL N-BK7 REV A	
APPROVAL	DD	18/FEB/13		
COPYRIGHT © 2013 BY THORLABS			ITEM #	APPROX WEIGHT
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS			FB1750-500	0.1 kg

FB1750-500 Transmission



ARROW POINTS IN DIRECTION
OF FILTER TRANSMISSION



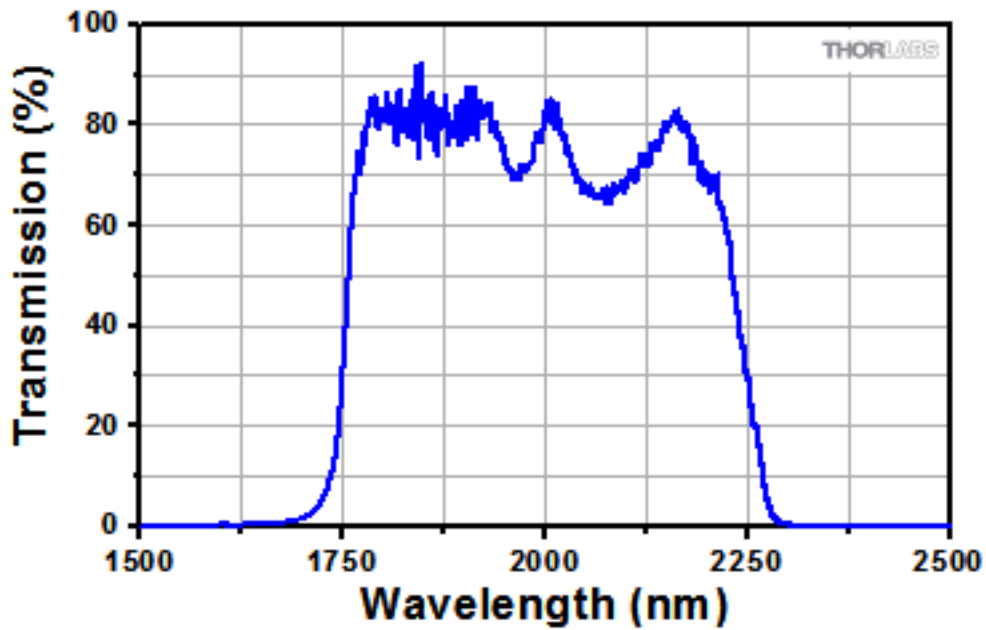
NOTES/SPECIFICATIONS:

1. CENTER WAVELENGTH (CWL): 2000nm
2. FULL WIDTH HALF MAXIMUM (FWHM): 500nm
3. TRANSMISSION MINIMUM: 70% AT CWL
4. OUT OF BAND TRANSMISSION: <0.1% FROM 0.200 μ m to 12 μ m
5. CLEAR APERTURE: 21.0mm
6. SURFACE QUALITY: 80-50 SCRATCH-DIG
7. OPERATING TEMPERATURE: -50° TO 80° C
8. EDGE TREATMENT: MOUNTED IN BLACK ANODIZED ALUMINUM RING
9. EDGE MARKINGS: CENTER WAVELENGTH-FULL WIDTH HALF MAX

FOR INFORMATION ONLY
NOT FOR MANUFACTURING PURPOSES

DRAWING PROJECTION			 www.thorlabs.com BANDPASS FILTER, CWL=2000nm, FWHM = 500nm	
NAME	DATE			
DRAWN	GG	18/FEB/13	MATERIAL	
APPROVAL	DD	18/FEB/13		
COPYRIGHT © 2013 BY THORLABS			N-BK7	
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS			ITEM #	APPROX WEIGHT
			FB2000-500	0.1 kg
			REV	A

FB2000-500 Transmission

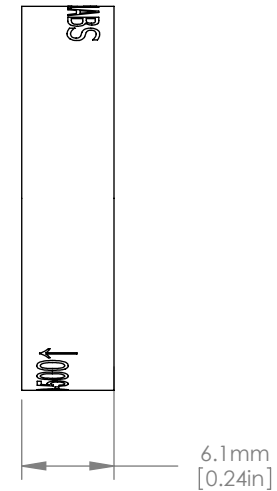
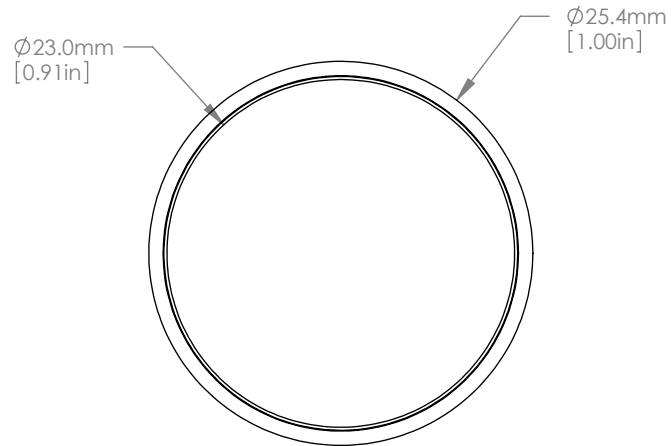


ARROW POINTS IN DIRECTION
OF FILTER TRANSMISSION

FB2250-500↑



ISOMETRIC VIEW FOR REFERENCE ONLY



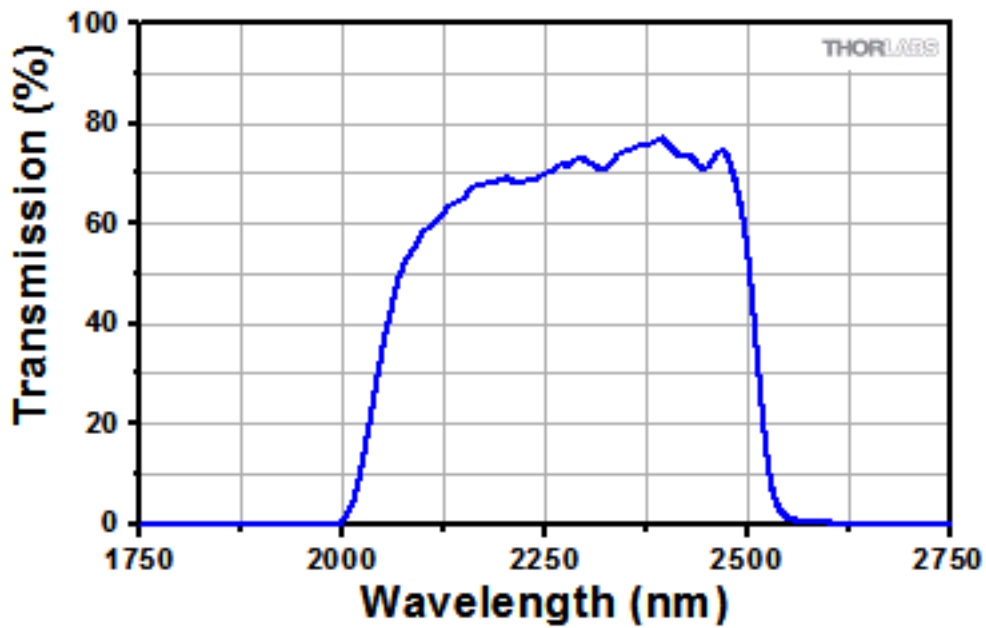
NOTES/SPECIFICATIONS:

1. CENTER WAVELENGTH (CWL): 2250nm
2. FULL WIDTH HALF MAXIMUM (FWHM): 500nm
3. TRANSMISSION MINIMUM: 70% AT CWL
4. OUT OF BAND TRANSMISSION: <0.1% FROM 0.200µm to 12µm
5. CLEAR APERTURE: 21.0mm
6. SURFACE QUALITY: 80-50 SCRATCH-DIG
7. OPERATING TEMPERATURE: -50° TO 80° C
8. EDGE TREATMENT: MOUNTED IN BLACK ANODIZED ALUMINUM RING
9. EDGE MARKINGS: CENTER WAVELENGTH-FULL WIDTH HALF MAX

FOR INFORMATION ONLY
NOT FOR MANUFACTURING PURPOSES

DRAWING PROJECTION			 www.thorlabs.com BANDPASS FILTER, CWL=2250nm, FWHM = 500nm	
NAME	DATE			
DRAWN	MG	07/DEC/10	MATERIAL SAPPHIRE	
APPROVAL	DD	07/MAR/12		
COPYRIGHT © 2010 BY THORLABS			ITEM #	APPROX WEIGHT
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS			FB2250-500	0.1 kg
			REV	A

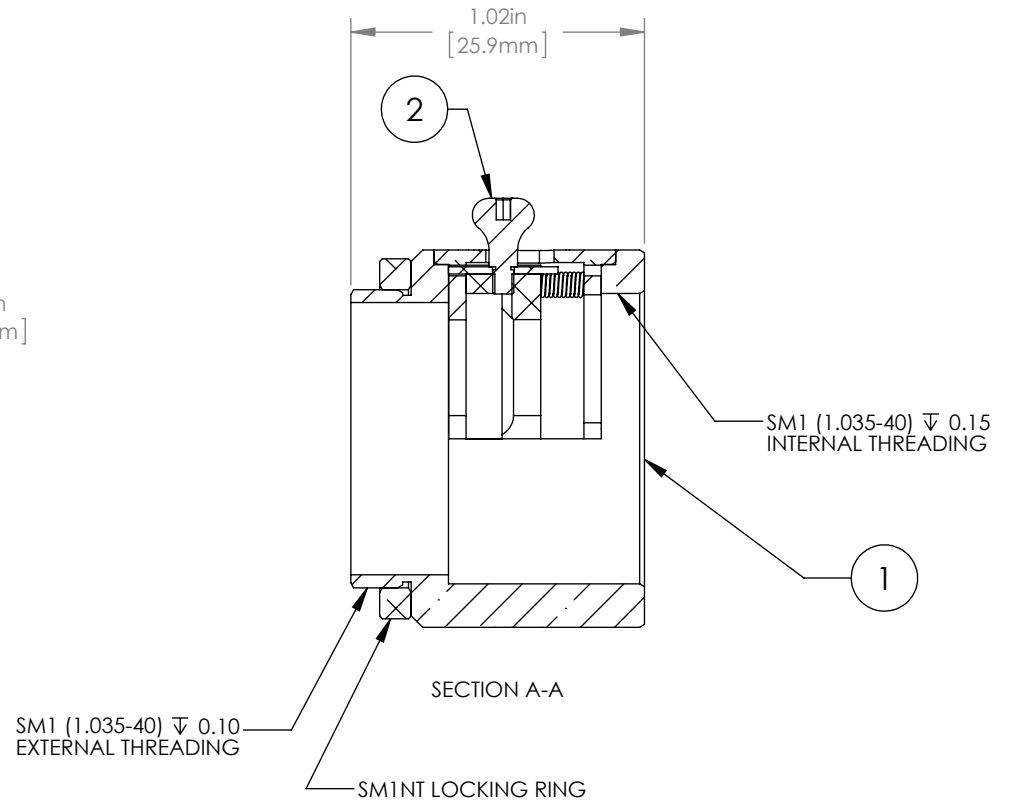
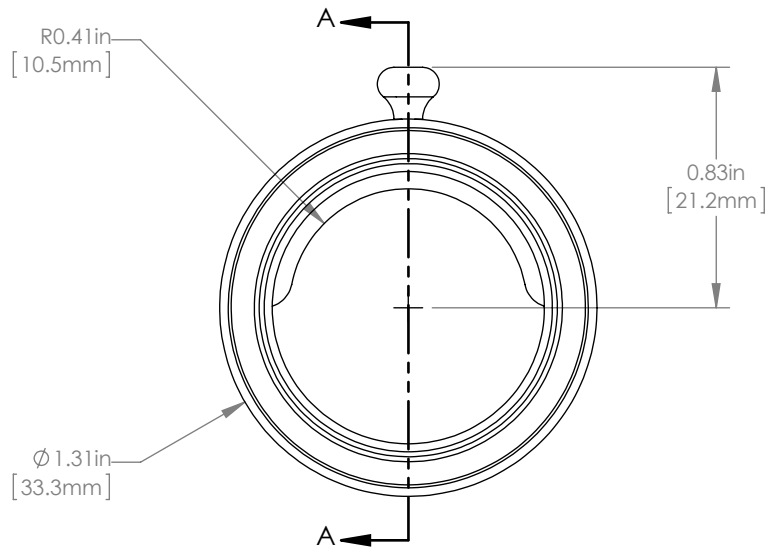
FB2250-500 Transmission



Allegato C9) Portafiltri a Sostituzione Rapida

Attachment C9) Fast Change Filters Holder

	PART NUMBER
①	SM1QB
②	SM1QT



NOTES/SPECIFICATIONS:

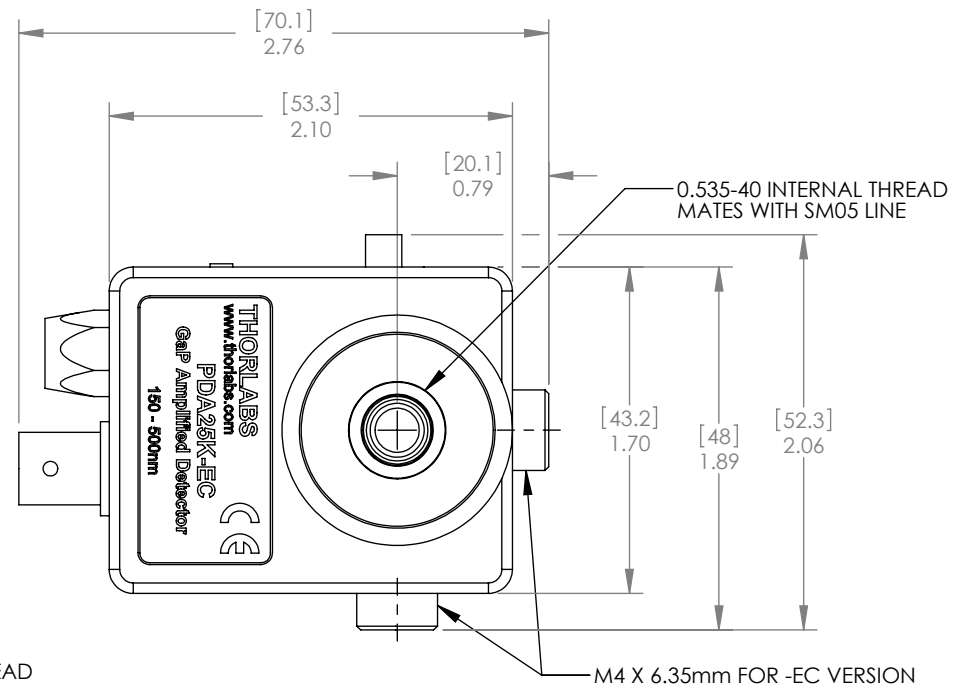
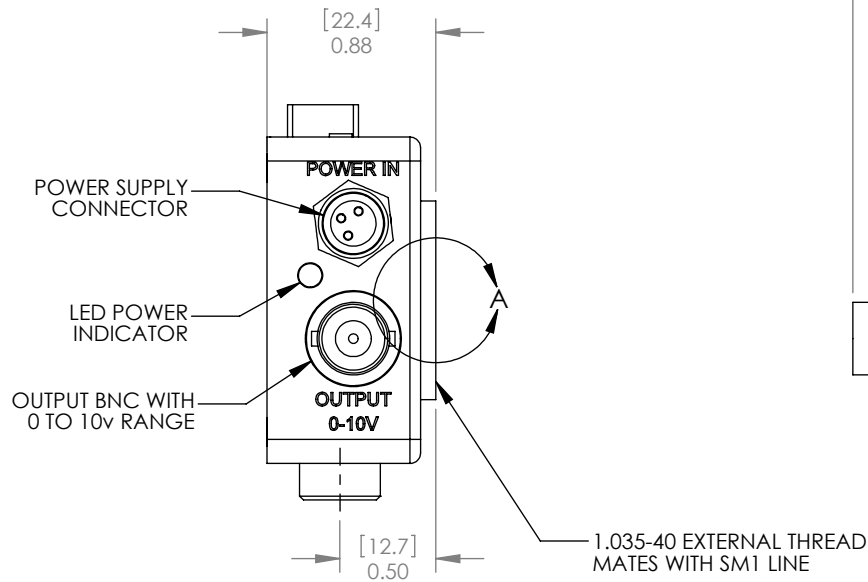
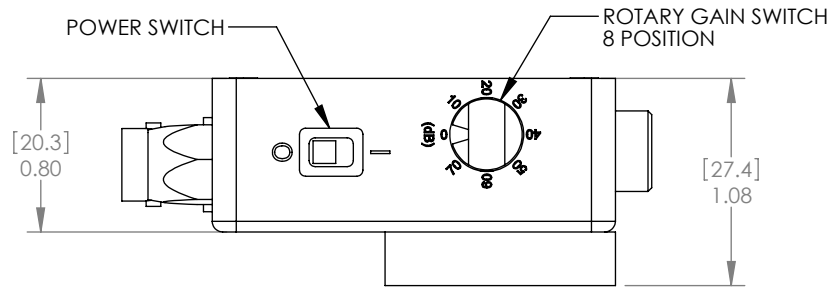
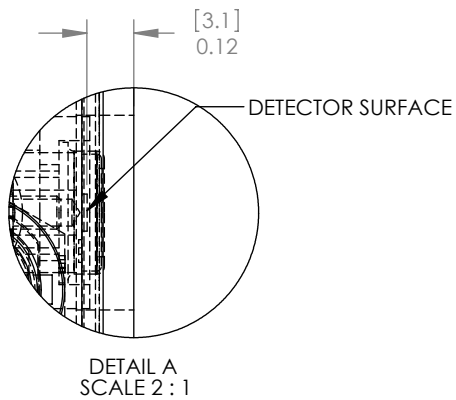
- FOR USE WITH $\varnothing 25.4\text{mm}$ or $\varnothing 25.0\text{mm}$ MOUNTED FILTERS 3.5-6.3mm THICK

FOR INFORMATION ONLY
NOT FOR MANUFACTURING PURPOSES

DRAWING PROJECTION			THORLABS www.thorlabs.com	
	NAME	DATE	SLOTTED LENS TUBE - PAIR	
DRAWN	CS	17/FEB/14	MATERIAL	
APPROVAL	DD	19/FEB/14	N/A	REV A
COPYRIGHT © 2014 BY THORLABS			ITEM #	APPROX WEIGHT
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS			SM1QP	0.022 kg

Allegato C10) Sensore Foto-elettrico UV

Attachment C10) UV Photo-Detector



THORLABS INC. PO BOX 366
NEWTON NJ

	NAME	DATE
DRAWN	EC	3/28/2006
ENG APPR.	EC	3/28/2006
MFG APPR.	EC	3/28/2006

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TITLE:
GaP Amplified Detector

MATERIAL: PDA25K SIZE A REV. C

SCALE: 1:1 SHEET 1 OF 1

DWG. NO. 13199-E0W PART NO. PDA25K-EC



PDA25K(-EC) **GaP Switchable Gain Detector**

User Guide



















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Chapter 1 Warning Symbol Definitions

Below is a list of warning symbols you may encounter in this manual or on your device.

Symbol	Description
	Direct Current
	Alternating Current
	Both Direct and Alternating Current
	Earth Ground Terminal
	Protective Conductor Terminal
	Frame or chassis Terminal
	Equipotentiality
	On (Supply)
	Off (Supply)
	In Position of a Bi-Stable Push Control
	Out Position of a Bi-Stable Push Control
	Caution, Risk of Electric Shock
	Caution, Hot Surface
	Caution, Risk of Danger
	Warning, Laser Radiation
	Caution, Spinning Blades May Cause Harm

Chapter 2 Description

The PDA25K is an amplified, switchable-gain, Gallium Phosphide (GaP) detector designed for detection of light signals over 150 to 550 nm wavelength range. An eight-position rotary switch allows the user to vary the gain in 10 dB steps. A buffered output drives 50 Ω load impedances up to 5 V. The PDA25K housing includes a removable threaded coupler (SM1T1) and retaining ring (SM1RR) that is compatible with any number of Thorlabs 1" threaded accessories. This allows convenient mounting of external optics, light filters, apertures, as well as providing an easy mounting mechanism using the Thorlabs cage assembly accessories.

Chapter 3 Setup

The detector can be set up in many different ways using our extensive line of adapters. However, the detector should always be mounted and secured for best operation.

1. Unpack the optical head, install a Thorlabs TR-series 1/2" diameter post into one of the #8-32 (M4 on -EC version) tapped holes, located on the bottom and side of the head, and mount into a PH-series post holder.
2. Connect the power supply 3-pin plug into the power receptacle on the PDA25K.
3. Plug the power supply into a 50 to 60 Hz, 100 to 120 VAC outlet (220 to 240 VAC for -EC version).
4. Attach a 50 Ω coax cable (i.e. RG-58U) to the output of the PDA. When running cable lengths longer than 12" we recommend terminating the opposite end of the coax with a 50 Ω resistor (Thorlabs Item # T4119) for maximum performance. Connect the remaining end to a measurement device such as an oscilloscope or high speed DAQ card. Caution: Many high speed oscilloscopes have input impedances of 50 Ω . In this case, do not install a 50 Ω terminator. The combined loads will equal 25 Ω which could allow ~135 mA of output current. This will damage the output driver of the PDA25K.
5. Power the PDA25K on using the power switch located on the top side of the unit.



Caution!



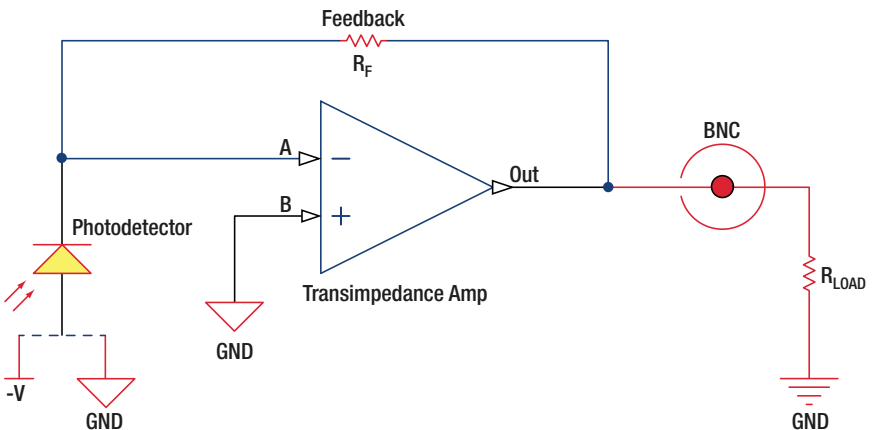
The PDA25K was designed to allow maximum accessibility to the photodetector by having the front surface of the diode flush with the outside of the PDA housing. When using fiber adapters, make sure that the fiber ferrule does not crash into the detector. Failure to do so may cause damage to the diode and/or the fiber. An easy way to accomplish this is to install a SM1RR retaining ring (included with the PDA25K) inside the 1" threaded coupler before installing the fiber adapter.

- Install any desired filters, optics, adapters, or fiber adapters to the input aperture. Caution: The PDA25K was designed to allow maximum accessibility to the photodetector by having the front surface of the diode flush with the outside of the PDA housing. When using fiber adapters, make sure that the fiber ferrule does not crash into the detector. Failure to do so may cause damage to the diode and/or the fiber. An easy way to accomplish this is to install a SM1RR retaining ring (included with the PDA25K) inside the 1" threaded coupler before installing the fiber adapter.
- Apply a light source to the detector. Adjust the gain to the desired setting.

Chapter 4 Operation

4.1. Theory of Operation

Thorlabs PDA series are ideal for measuring both pulsed and CW light sources. The PDA25K includes a reverse-biased PIN photo diode, mated to a switchable gain transimpedance amplifier, and packaged in a rugged housing.



4.2. Responsivity

The responsivity of a photodiode can be defined as a ratio of generated photocurrent (I_{PD}) to the incident light power (P) at a given wavelength:

$$R(\lambda) = \frac{I_{PD}}{P}$$

4.3. Dark Current

Dark current is leakage current which flows when a bias voltage is applied to a photodiode. The PDA with Transimpedance Amplifier does control the dark current flowing out. Looking at the figure above, it can be noted that Point B is held at ground and the amplifier will try to hold point A to “Virtual Ground”. This minimizes the effects of dark current present in the system.

The dark current present is also affected by the photodiode material and the size of the active area. Silicon devices generally produce low dark current compared to germanium devices which have high dark currents. The table below lists several photodiode materials and their relative dark currents, speeds, sensitivity, and costs.

Material	Dark Current	Speed	Sensitivity ¹ (nm)	Cost
Silicon (Si)	Low	High	400 – 1000	Low
Germanium (Ge)	High	Low	900 – 1600	Low
Gallium Phosphide (GaP)	Low	High	150 – 550	Med
Indium Gallium Arsenide (InGaAs)	Low	High	800 – 1800	Med
Extended Range: Indium Gallium Arsenide (InGaAs)	High	High	1200 – 2600	High

4.4. Bandwidth and Response

A load resistor will react with the photodetector junction capacitance to limit the bandwidth. For best frequency response, a 50 Ω terminator should be used in conjunction with a 50 Ω coaxial cable. The gain of the detector is dependent on the feedback element (R_F). The bandwidth of the detector can be calculated using the following:

$$f(-3dB) = \sqrt{\frac{GBP}{4\pi R_f \times C_D}}$$

Where GBP is the amplifier gain bandwidth product and C_D is the sum of the photodiode junction capacitance and the amplifier capacitance.

¹ Approximate values, actual wavelength values will vary from unit to unit

4.5. Terminating Resistance

A load resistance is used to convert the generated photocurrent into a voltage (V_{OUT}) for viewing on an oscilloscope:

Depending on the type of the photodiode, load resistance can affect the response speed. For maximum bandwidth, we recommend using a 50 Ω coaxial cable with a 50 Ω terminating resistor at the opposite end of the cable. This will minimize ringing by matching the cable with its characteristic impedance. If bandwidth is not important, you may increase the amount of voltage for a given light level by increasing R_{LOAD} . In an unmatched termination the length of the coaxial cable can have a profound impact on the response, so it is recommended to keep the cable as short as possible.

The maximum output of the PDA25K is 10 volts for high impedance loads (i.e. $R_{Load} > 5 \text{ k}\Omega$) and 5 volts for 50 Ω loads. Adjust the gain so that the measured signal level out of the PDA25K is below 10 volts (5 volts with a 50 Ω load) to avoid saturation.

For low terminating resistors, $<5 \text{ k}\Omega$ or 1% error, an additional factor needs to be included in the above formula. As described above the output includes a 50 Ω series resistor (R_S). The output load creates a voltage divider with the 50 Ω series resistor as follows:

$$Scale\ Factor = \frac{R_{Load}}{R_{Load} + R_S}$$

$$V_{OUT} = \mathcal{R}(\lambda) * Transimpedance\ Gain * Scale\ Factor * Input\ Power\ (W)$$

4.6. Gain Adjustment

The PDA25K includes a low-noise, low-offset, high-gain transimpedance amplifier that allows gain adjustment over a 70 dB range. The gain is adjusted by rotating the gain control knob, located on the top side of the unit. There are 8 gain positions incremented in 10 dB steps. It is important to note that the bandwidth will decrease as the gain increases. See the specifications table in **Chapter 6** to choose the best gain vs. bandwidth for a given input signal.

Chapter 5 Troubleshooting

Problem	Suggested Solutions
There is no signal response.	Verify that the power is switched on and all connections are secure.
	Verify the proper terminating resistor is installed if using a Voltage measurement device.
	Verify that the optical signal wavelength is within the specified wavelength range.
	Verify that the optical signal is illuminating the detector active area.
Output Voltage will not increase. Detector Output is skewed.	Check to make sure the detector is not saturated. Refer to the Output Voltage spec in the Specifications table. Install a 1" Lens Tube (SM1L10) to the thread coupler (SM1T1) to baffle any external light sources to see if this improves the response.

Chapter 6 Specifications²

Performance Specifications			
0 dB Setting		40 dB Setting	
Gain ³ (Hi-Z)	1.51 x 10 ³ V/A ± 2%	Gain ³ (Hi-Z)	1.51 x 10 ⁵ V/A ± 2%
Gain ³ (50 Ω)	0.75 x 10 ³ V/A ± 2%	Gain ³ (50 Ω)	0.75 x 10 ⁵ V/A ± 2%
Bandwidth	7.5 MHz	Bandwidth	100 kHz
Noise (RMS)	350 μV	Noise (RMS)	325 μV
NEP (@ λ _p)	3.0 x 10 ⁻¹⁰ W/√Hz	NEP (@ λ _p)	1.6 x 10 ⁻¹¹ W/√Hz
Offset	±5 mV (10 mV Max)	Offset	±10 mV (20 mV Max)
10 dB Setting		50 dB Setting	
Gain ³ (Hi-Z)	4.75 x 10 ³ V/A ± 2%	Gain ³ (Hi-Z)	4.75 x 10 ⁵ V/A ± 2%
Gain ³ (50 Ω)	2.38 x 10 ³ V/A ± 2%	Gain ³ (50 Ω)	2.38 x 10 ⁵ V/A ± 2%
Bandwidth	3.3 MHz	Bandwidth	32 kHz
Noise (RMS)	290 μV	Noise (RMS)	500 μV
NEP (@ λ _p)	1.0 x 10 ⁻¹⁰ W/√Hz	NEP (@ λ _p)	1.7 x 10 ⁻¹¹ W/√Hz
Offset	±6 mV (12 mV Max)	Offset	±15 mV (40 mV Max)
20 dB Setting		60 dB Setting	
Gain ³ (Hi-Z)	1.5 x 10 ⁴ V/A ± 2%	Gain ³ (Hi-Z)	1.5 x 10 ⁶ V/A ± 5%
Gain ³ (50 Ω)	0.75 x 10 ⁴ V/A ± 2%	Gain ³ (50 Ω)	0.75 x 10 ⁶ V/A ± 5%
Bandwidth	1.0 MHz	Bandwidth	11 kHz
Noise (RMS)	260 μV	Noise (RMS)	675 μV
NEP (@ λ _p)	4.0 x 10 ⁻¹¹ W/√Hz	NEP (@ λ _p)	1.0 x 10 ⁻¹¹ W/√Hz
Offset	±6 mV (15 mV Max)	Offset:	±20 mV (75 mV Max)
30 dB Setting		70 dB Setting	
Gain ³ (Hi-Z)	4.75 x 10 ⁴ V/A ± 2%	Gain ³ (Hi-Z)	4.75 x 10 ⁶ V/A ± 5%
Gain ³ (50 Ω)	2.38 x 10 ⁴ V/A ± 2%	Gain ³ (50 Ω)	2.38 x 10 ⁶ V/A ± 5%
Bandwidth	300 kHz	Bandwidth	3.3 kHz
Noise (RMS)	245 μV	Noise (RMS)	900 μV
NEP (@ λ _p)	2.0 x 10 ⁻¹¹ W/√Hz	NEP (@ λ _p)	7.0 x 10 ⁻¹² W/√Hz
Offset	±8 mV (15 mV Max)	Offset	±40 mV (200 mV Max)

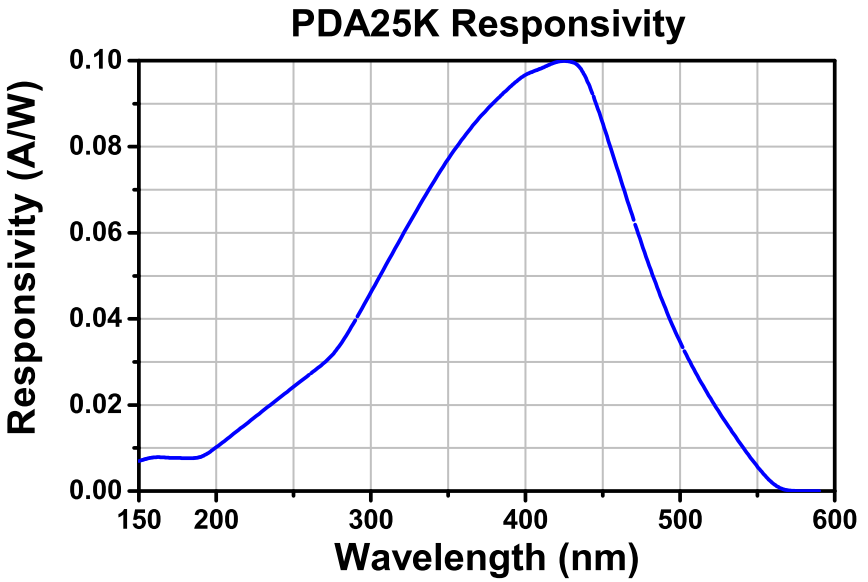
² All measurements performed with a 50 Ω load unless stated otherwise.

³ The PDA25K has a 50 Ω series terminator resistor (i.e. in series with amplifier output). This forms a voltage divider with any load impedance (e.g. 50 Ω load divides signal in half).

Electrical Specifications		
Detector		GaP PIN
Active Area		2.2 mm x 2.2 mm (4.8 mm ²)
Wavelength Range	λ	150 to 550 nm
Peak Wavelength	λ_p	440 nm (Typ.)
Peak Response	$\Re(\lambda_p)$	0.12 A/W (Typ.)
Amplifier GBP		25 MHz
Output Impedance		50 Ω
Max Ouput Current	I_{OUT}	100 mA
Load Impedance		50 Ω to Hi-Z
Gain Adjustment Range		0 dB to 70 dB
Gain Steps		8 x 10 dB Steps
Output Voltage	V_{OUT}	0 to 5 V (50 Ω) 0 to 10 V (Hi-Z)
General		
On/Off Switch		Slide
Gain Switch		8 Position Rotary
Output		BNC (DC Coupled)
Package Size		2.76" x 2.06" x 0.88" (70.1 mm x 52.3 mm x 22.4 mm)
PD Surface Depth		0.16" (4.1 mm)
Weight, Detector Only		0.15 lbs
Accessories		SM1T1 Coupler SM1RR Retaining Ring
Operating Temp		0 to 40 °C
Storage Temp		-55 to 125 °C
AC Power Supply		AC – DC Converter
Input Power ⁴		31 W 100 - 200 VAC (50 to 60 Hz) 220 - 240 VAC (50 to 60 Hz)

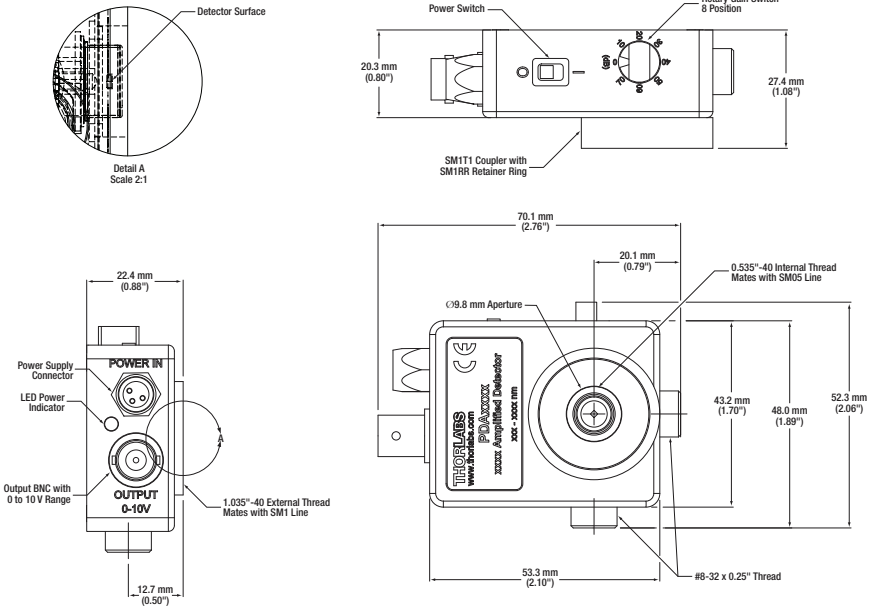
⁴ Although the power supply is rated for 31 W the PDA25K actual usage is <5 W over the full operating range.

6.1. Response Curve



6.2. Mechanical Drawing

Visit the web for a more detailed mechanical drawing.



Chapter 7 Certificate of Conformance

Konformitätserklärung Declaration of Conformity Déclaration de Conformité

Thorlabs Inc
56 Sparta Ave.
Newton, NJ
USA

erklärt in alleiniger Verantwortung, dass das Produkt:
declares under it's own responsibility, that the product:
déclare sous notre seule responsabilité, que le produit:

PDA10A, PDA8A, PDF10A, PDA36A, PDA100A, PDA8A/M, PDF10A/M, PDA36A-EC,
PDA10AEC, PDA100A-EC, PDA10CF, PDA10CS, PDF10C, PDA10D, PDA10CF-EC,
PDA10CS-EC, PDF10C/M, PDA10D-EC, PDA50B, PDA50B-EC, PDA30G, PDA20H,
PDA30G-EC, PDA20H-EC, PDA25K, PDA25K-EC, DET25K, DET25K/M, DET10A,
DET36A, DET100A, DET100A/M, DET10A/M, DET36A/M, DET50B, DET50B/M, DET20C,
DET20C/M, DET30B, DET30B/M, PDA30B, PDA30B-EC, DET10D, DET10D/M, PDA20C,
PDA20C/M, PDA20CS, PDA20CS-EC, DET01CFC, DET01CFC/M, DET02AFC,
DET02AFC/M

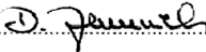
mit den Anforderungen der Normen
fulfills the requirements of the standard
satisfait aux exigences des normes

2006/95 EC
EMC 2004/108/EC
EN 61010-1:2001
EN 61326-1:2006
CISPR 11 Edition 4:2003
CISPR 11 Edition 4:2003
IEC 61000-3-2,
IEC 61000-3-3
IEC 61000-4-2
IEC 61000-4-3
IEC 61000-4-4
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-6
IEC 61000-4-6
IEC 61000-4-11

Low Voltage Directive 12.Dec. 2006
Electromagnetic Compatibility Directive
Safety of Test and Measurement Equipment
EMC of Test and Measurement Equipment
Conducted Emissions
Radiated Emissions
Harmonics
Voltage Fluctuation and Flicker
Electrostatic Discharge
Radiated Immunity
Electrical Fast Transient/Burst, Power Leads
Electrical Fast Transient/Burst, I/O Leads
Surge Immunity, Power Leads
Conducted Immunity, Power Leads
Conducted Immunity, I/O Leads
Voltage Dips, Interrupts and Variations

übereinstimmt und damit den Bedingungen entspricht.
and therefore corresponds to the regulations of the directive.
et répond ainsi aux dispositions de la directive.

Dachau, 27. Februar 2012


.....

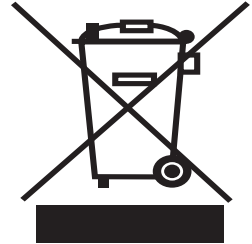
Ort und Datum der Ausstellung
Place and date of issue
Lieu et date d'établissement

Name und Unterschrift des Befugten
Name and signature of authorized person
Nom et signature de la personne autorisée

Chapter 8 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated



Wheelie Bin Logo

As the WEEE directive applies to self contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e.g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

8.1. Waste Treatment is Your Own Responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

8.2. Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

Chapter 9 Thorlabs Worldwide Contacts

USA, Canada, and South America

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Fax: +86 (0)21-32513480
www.thorlabs.hk
Email: chinasales@thorlabs.com



THORLABS

www.thorlabs.com

Allegato C11) Sensore Foto-elettrico IR

Attachment C11) IR Photo-Detector

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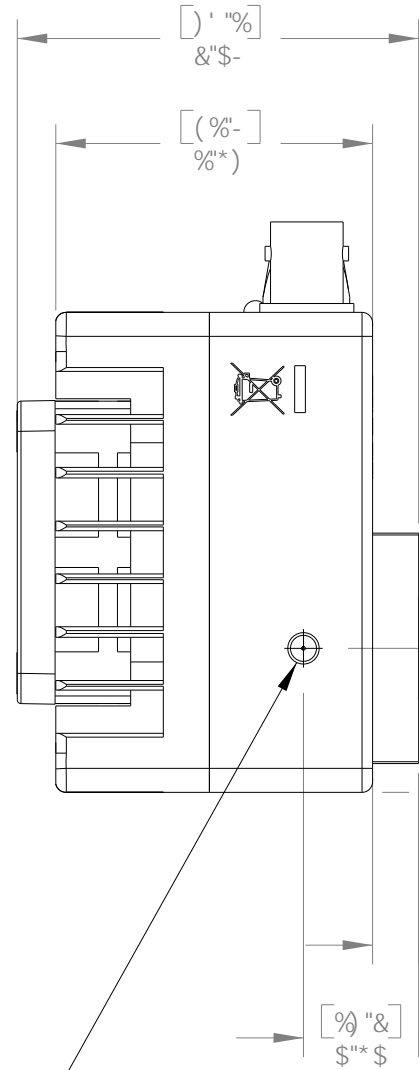
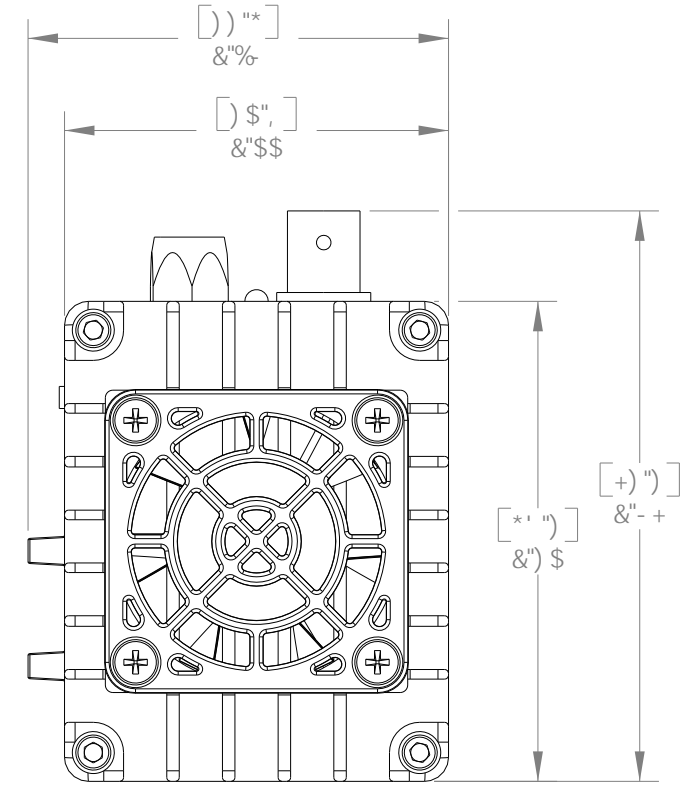
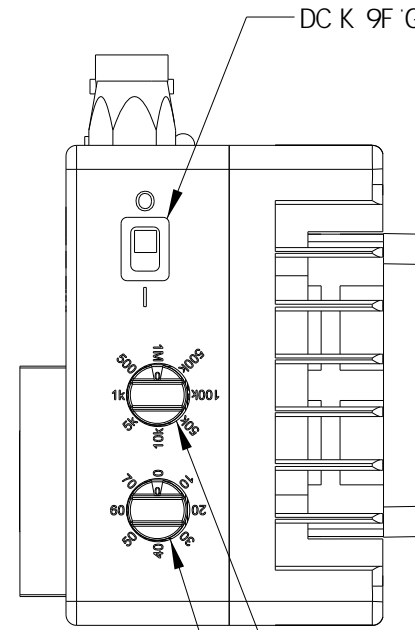
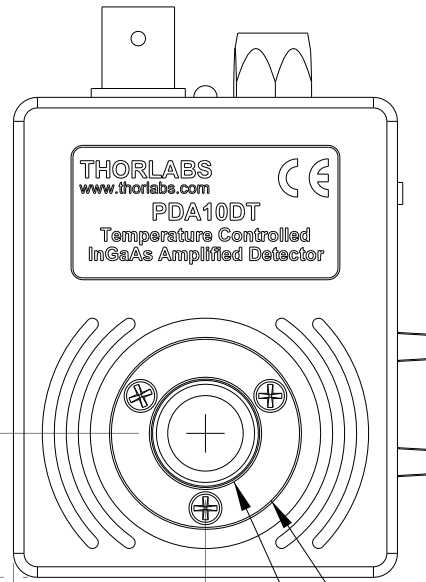
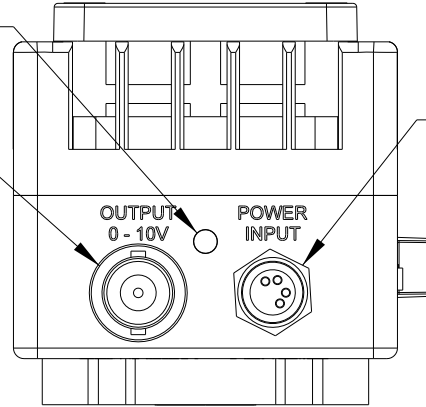
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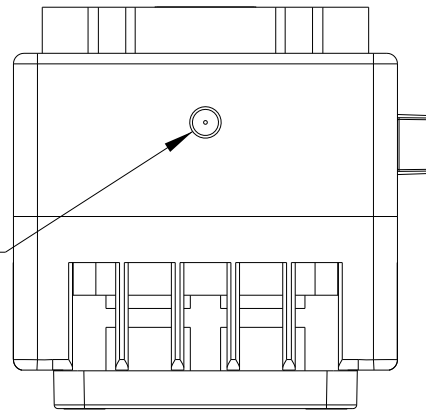
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FC H5FM; 5-B 'GK #7 < , 'DC G#C B

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, !' &L '\$&) "Hk F958 fA ('L *"') a a : CF!97 'J 9FG€ Bt



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I B @9GC Hk 9FK €9 GD97 ÷ 98.	8F5K B	97 * #9) # \$+
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D9FD9B 8 7 I € F #M '\$ "\$ \$&		
Hk F958. '7 €GG &: #		

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H# @9. H97 'b; U5g5A D@= 98 'D<C HC 89H97 HC F

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8K ; "'BC "	D5FH 'BC "	
% %&- !9\$%	D85 %\$8H	



PDA10DT(-EC)
Amplified InGaAs Detector

User Guide



















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Chapter 1 Warning Symbol Definitions

Below is a list of warning symbols you may encounter in this manual or on your device.

Symbol	Description
	Direct Current
	Alternating Current
	Both Direct and Alternating Current
	Earth Ground Terminal
	Protective Conductor Terminal
	Frame or chassis Terminal
	Equipotentiality
	On (Supply)
	Off (Supply)
	In Position of a Bi-Stable Push Control
	Out Position of a Bi-Stable Push Control
	Caution, Risk of Electric Shock
	Caution, Hot Surface
	Caution, Risk of Danger
	Warning, Laser Radiation
	Caution, Spinning Blades May Cause Harm

Chapter 2 Description

The PDA10DT is an amplified, thermoelectrically cooled, switchable-gain, switchable-bandwidth, InGaAs photoconductive detector. The detector is DC coupled. It is sensitive over a wavelength range of 0.9 to 2.57 μm . Two eight-position rotary switches allow the user to vary the gain in 10 dB steps and select low-pass filter bandwidth settings from 500 Hz to 1 MHz. A buffered output drives 50 Ω load impedances up to 5 V. The first two gain steps (0 dB and 10 dB) are biased to -2 V for best high-speed performance while the remaining gain steps are unbiased for high precision measurements.

The detector is mounted on a thermoelectric cooler and factory set to cool the detector to -10 $^{\circ}\text{C}$ with a thermistor providing feedback to maintain a constant temperature. This cooling provides higher detectivity (D^*), which results in a lower offset at the output and allows higher gains. It also reduces thermally generated noise. The housing acts as a heat sink and includes a fan to increase the cooling capacity. It is important to note that the cooling fan will keep the heat sink at room temperature. Without it, the heat sink will warm up, causing a higher temperature drop from the heat sink to the detector element, resulting in larger TEC currents. Without the fan, the TEC current will operate at its limit (~820 mA) and the detector element will no longer be temperature stabilized. Offsets will increase and fluctuate, and output noise will increase. For best results do not block, limit airflow to, or stop the cooling fan.

The detector housing has an internally SM1-threaded (1.035"-40) mounting aperture, which is compatible with any SM1-threaded accessory. The device ships with a SM1RR Retaining Ring allowing convenient mounting of optics, light filters, apertures, etc. The SM1-threaded mount can be easily integrated into our cage and lens tube systems.

The PDA10DT has two 8-32 tapped holes for mounting the detector on a $\text{\O}1/2$ " TR Post in one of two perpendicular directions and comes with a 120 VAC power supply.

The PDA10DT-EC has two M4 tapped mounting holes instead, which is compatible with our metric TR Posts and comes with a 230 VAC power supply.

Chapter 3 Setup



Figure 1 Electrical Connections

1. Unpack the detector head
2. (Optional) Install a Thorlabs $\text{\O}1/2$ " diameter TR Post (not included) into one of the 8-32 tapped holes (M4 in –EC version) located on the bottom and side of the head, and mount into a PH Post Holder (not included).
3. Connect the 4-pin power supply plug into the power receptacle on the PDA10DT.
4. Plug the power supply into a 50 to 60 Hz, 100 to 120 VAC outlet (220 – 240 VAC for –EC version).
5. Attach a 50 Ω BNC cable to the output of the PDA. When running cable lengths longer than 12", we recommend terminating the opposite end of the coax with a 50 Ω resistor (Thorlabs' T4119 BNC in-line terminator) for maximum performance. Connect the remaining end to a measurement device such as an oscilloscope or high-speed DAQ card.



6. Turn on the PDA10DT using the power switch located on the top side of the detector.
7. Install any desired filters, optics, adapters, or fiber adapters to the input aperture.

**CAUTION**

The PDA10DT was designed to allow maximum accessibility to the photodetector by having the front surface of the diode flush with the outside of the PDA housing. When using fiber adapters, make sure that the fiber ferrule does not crash into the detector. Failure to do so may cause damage to the diode and/or the fiber. Installing an SM1RR Retaining Ring (included) inside the 1" threaded coupler *before* installing the fiber adapter will prevent damage.

8. Apply a light source to the detector. Adjust the gain to the desired setting.

**CAUTION**

Saturation of the output signal may cause damage to the InGaAs detector element.

Note: Allow a minute for the TEC controller to stabilize the temperature. For best results, allow the unit to warm up for about 30 minutes.

Chapter 4 Operation

This device is a photovoltaic detector and requires a chopped or pulsed input source with a wavelength range from 0.9 to 2.57 μm . The DC-coupled amplifier circuit is designed to minimize noise.

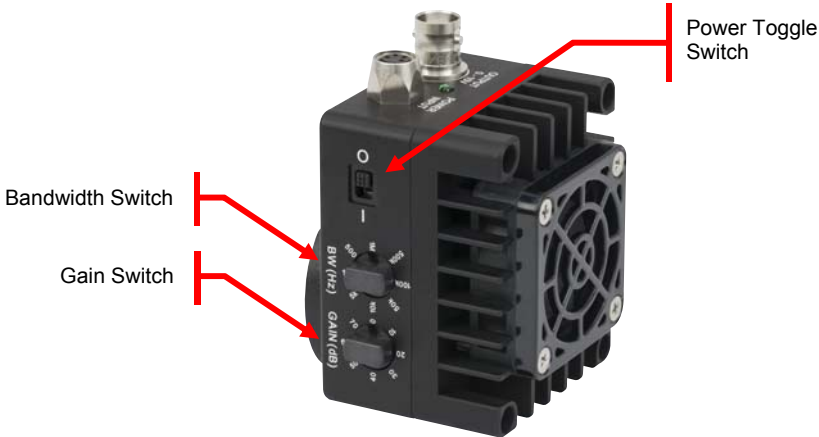


Figure 2 Gain Control, LPF Control, and Power Selector

4.1. Output

The maximum output of the PDA10DT is 10 V for high impedance loads (i.e. $R_{\text{LOAD}} \geq 5 \text{ k}\Omega$) and 5 V for 50 Ω loads. Adjust the gain so that the measured signal level out of the PDA10DT is below 10 V (5 V for a 50 Ω load) to avoid saturation. If necessary, use external neutral density filters to reduce the input light level. The BNC output signal is buffered with an amplifier capable of driving 50 Ω loads. A 50 Ω series resistor is included on the output to impedance match a 50 Ω coax cable. For best performance, we recommend operating the PDA10DT with a 50 Ω terminating load located at the end of the coax cable. While this is not necessary, it eliminates ringing and distortion due to impedance mismatches.

4.2. Gain Adjustment

The PDA10DT includes a low-noise, low-offset, high-gain amplifier that allows gain adjustment over a 70 dB range. The gain is adjusted by rotating the gain control knob located on the side of the unit. There are 8 gain positions incremented in 10 dB steps. To adjust the gain, follow the steps below.

- 1) Set the Gain Switch to 0 dB.
- 2) Turn on the light source.
- 3) Adjust the gain setting making sure the output of the detector is below the saturation level as indicated by section 4.1 above.

4.3. Bandwidth Filter Adjustment

The PDA10DT also includes an adjustable low-pass filter with settings from 500 Hz to 1 MHz in 8 steps. This filter allows the user to optimize the PDA10DT to operate at the lowest amount of high-frequency optical and electrical noise. The filter is adjusted by rotating the filter control knob, located on the side of the unit. To adjust the filter, follow the steps below:

- 1) Determine the maximum bandwidth required.
- 2) Set the filter bandwidth switch setting just above the desired bandwidth.

4.4. Thermoelectric Cooler

The thermoelectric cooler built into the detector is factory set to cool the detector to -10 °C with a thermistor providing feedback to maintain a constant temperature. The housing is used as a heat sink and includes a fan to increase the cooling capacity. It is important to note that the cooling fan will keep the heat sink at room temperature. Without it, the heat sink will warm up, causing a higher temperature drop from the heat sink to the detector element, resulting in larger TEC currents. Without the fan, the TEC current will operate at its limit (~820 mA) and the detector element will no longer be temperature stabilized. Offsets will increase and fluctuate, and output noise will increase. For best results do not block, limit airflow to, or stop the cooling fan. This operation is automatic and requires no input or adjustment by the user.

4.5. Light-to-Voltage Conversion

The Spectral Responsivity, $\mathfrak{R}(\lambda)$, can be obtained Spectral Response Curve on page 15 to estimate the amount of output voltage to expect. The light-to-Voltage conversion can be estimated by factoring the wavelength-dependent responsivity of the InGaAs detector with the gain as shown below:

$$V_{out} (V) = \text{Gain} \frac{V}{A} * \mathfrak{R}(\lambda) \frac{A}{W} * \text{Input Power (W)}$$

For terminators with low resistance, <5 k Ω or 1% error, an additional factor needs to be included in the above formula. As described above, the output includes a 50 Ω series resistor (R_S). The output load creates a voltage divider with the 50 Ω series resistor as follows:

$$\text{Scale Factor} = \frac{R_{LOAD}}{(R_{LOAD} + R_S)}$$

Where R_{LOAD} is the terminating resistor and $R_S = 50 \Omega$. For a standard 50 Ω terminator, the gain will be scaled by 0.5 as shown below:

$$\text{Scale Factor} = \frac{50 \Omega}{(50 \Omega + 50 \Omega)} = 0.5$$

$$V_{out} (V) = \text{Gain} \frac{V}{A} * \mathfrak{R}(\lambda) \frac{A}{W} * \text{Input Power (W)} * \text{Scale Factor}$$

Chapter 5 Maintenance

There are no serviceable parts in the PDA10DT detector or power supply. The housing may be cleaned by wiping with a soft damp cloth. The window of the detector should only be cleaned using isopropyl alcohol and optical grade wipes. If you suspect a problem with your PDA10DT, please contact your local Thorlabs technical support office and a member of our support team will be happy to assist you.

Chapter 6 Specifications

Specifications ¹	
Optical Specifications	
Wavelength Range	0.9 – 2.57 μm
Peak Wavelength (λ_p)	2.3 μm
Peak Response (λ_p)	1.32 A/W (Typ)
Electrical Specifications	
Gain Adjustment Range	70 dB
Gain Steps	8
Gain Settings (dB)	0, 10, 20, 30, 40, 50, 60, 70
Filter Steps	8
Filter Settings (kHz)	0.5, 1, 5, 10, 50, 100, 500, 1000
Output Voltage² (50 Ω)	0 – 5 V
(Hi-Z)	0 – 10 V
Output Impedance	50 Ω
Max Output Current	100 mA
Load Impedance	50 Ω – Hi-Z
Offset³	20 mV (Typ) 45 mV (Max)
Offset Drift (70dB)	2.7 mV/ $^{\circ}\text{C}$
TEC Temperature	-10 $^{\circ}\text{C}$
Bias Voltage	-2 V (0 dB and 10 dB) 0 V (20 dB to -70 dB)

¹ All measurements performed with a 50 Ω load unless stated otherwise. The PDA10DT has a 50 Ω series terminator resistor (i.e., in series with amplifier output). This forms a voltage divider with any load impedance (e.g., 50 Ω load divides signal in half).

² Saturation of the output voltage may cause damage to the InGaAs detector element.

³ After the temperature has stabilized on all gain steps. Also note, the worst case offset is on the 10 dB gain step.

General	
Detector	Extended InGaAs PIN
Active Area Diameter	0.8 mm ² (Ø 1.0 mm)
Surface Depth	0.08" (2.0 mm)
Output	BNC
Weight (Detector/Power Supply)	0.42 lbs / 2.1 lbs (191 g / 955 g)
Power Supply	31 W
Input Power	100 – 120 VAC, 50 – 60 Hz (220 – 240 VAC –EC)
Storage Temperature	0 to 85 °C
Operating Temperature	0 to 30 °C
Accessories	SM1RR
Optical Head Size	3" x 2.2" x 2.2" (76.2 mm x 55.9 mm x 55.9 mm)
Gain/LPF Switches	8-Pos Rotary
Gain Steps	8 x 10 dB steps
Filter Steps	8
Gain Adjustable Range	70 dB

Gain and Low-Pass Filter Specifications					
Gain (Hi-Z) ⁴		Low-Pass Filter Bandwidth		NEP Values (@ 1 MHz, 50 Ω)	
0 dB	1.51 kV/A	1M	1 MHz	0 dB	2.71 x 10 ⁻¹¹ W/√Hz
10 dB	4.75 kV/A	500k	500 kHz	10 dB	8.67 x 10 ⁻¹² W/√Hz
20 dB	15.0 kV/A	100k	100 kHz	20 dB	3.78 x 10 ⁻¹² W/√Hz
30 dB	47.5 kV/A	50k	50 kHz	30 dB	1.78 x 10 ⁻¹² W/√Hz
40 dB	151 kV/A	10k	10 kHz	40 dB	1.37 x 10 ⁻¹² W/√Hz
50 dB	475 kV/A	5k	5 kHz	50 dB	7.73 x 10 ⁻¹³ W/√Hz
60 dB	1500 kV/A	1k	1 kHz	60 dB	8.24 x 10 ⁻¹³ W/√Hz
70 dB	4750 kV/A	500	500 Hz	70 dB	6.37 x 10 ⁻¹³ W/√Hz

⁴ Gain with a 50 Ω load is one-half the Hi-Z gain. All values are ±2%.

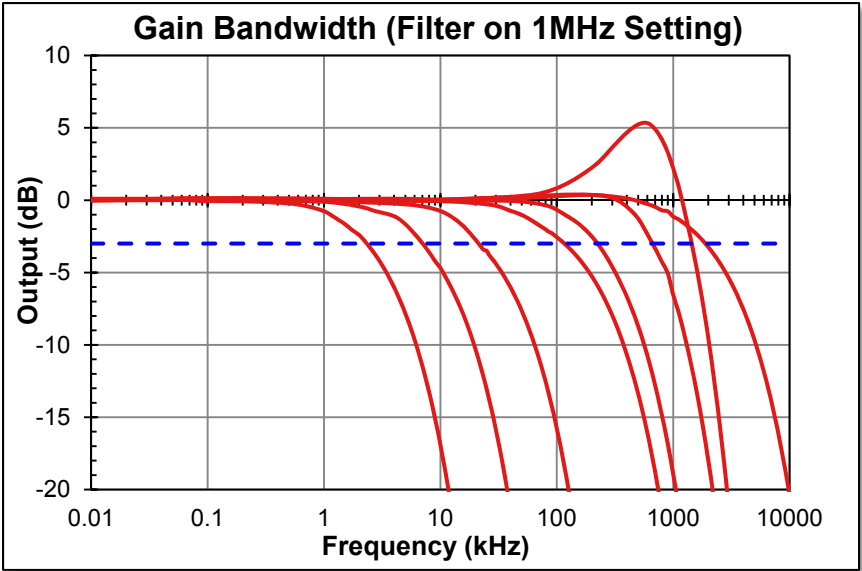


Figure 3 PDA10DT Gain Bandwidth

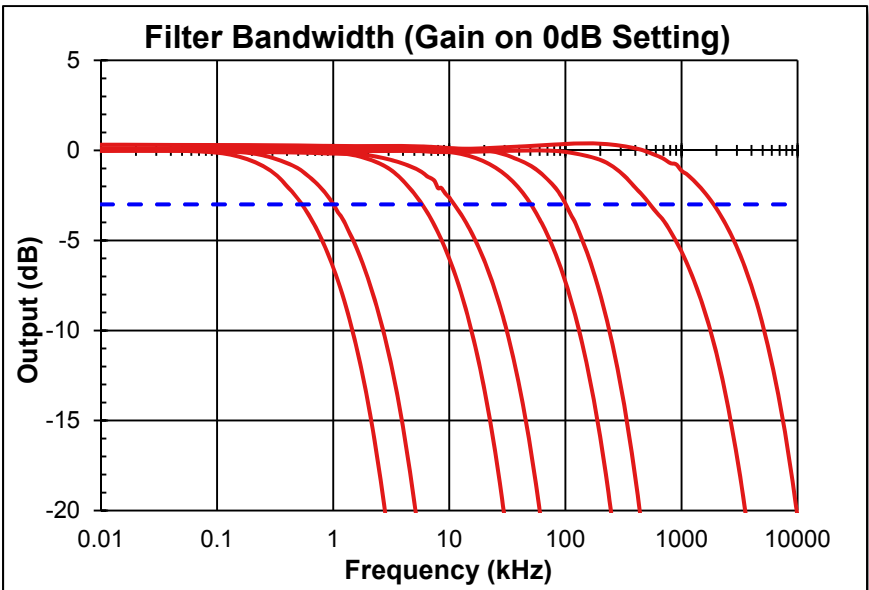


Figure 4 PDA10DT Filter Bandwidth

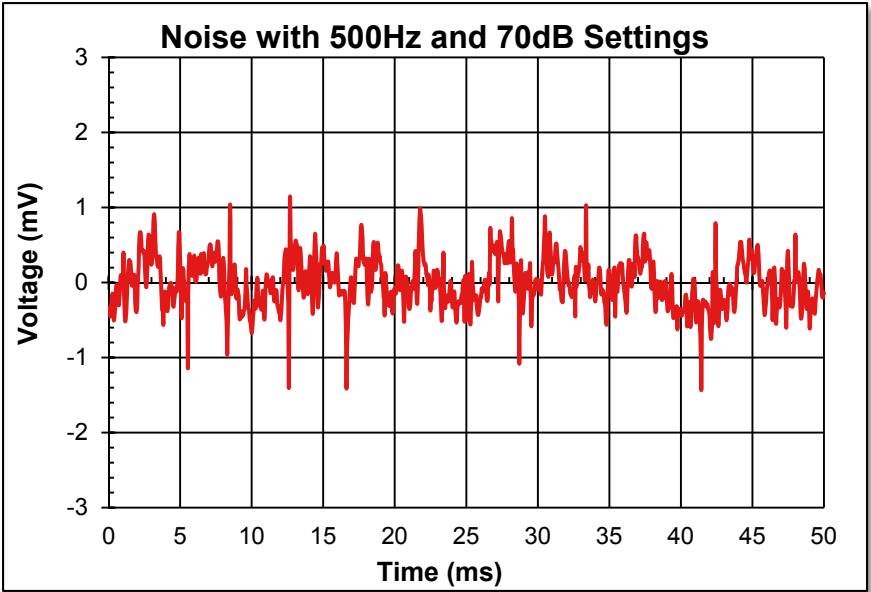


Figure 5 Noise at 500 Hz Bandwidth and 70 dB Gain

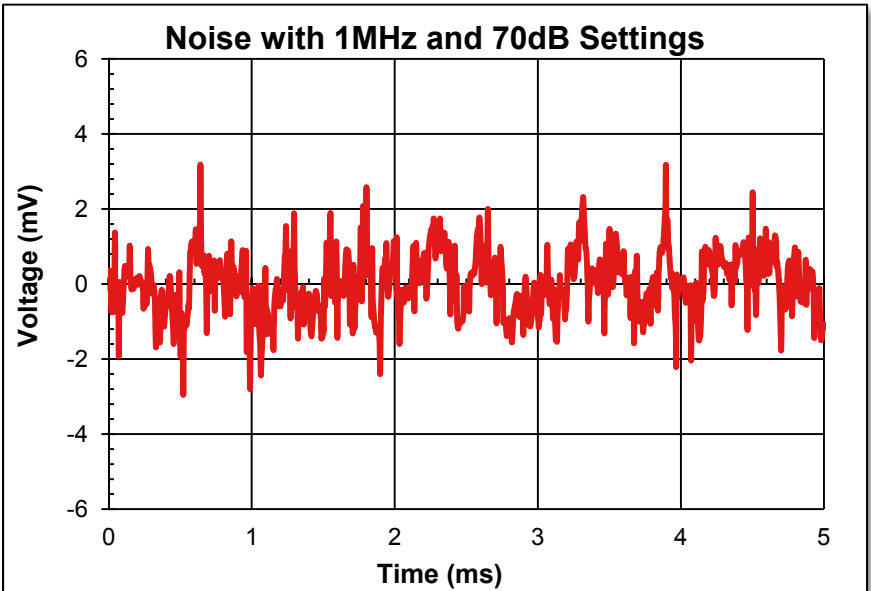
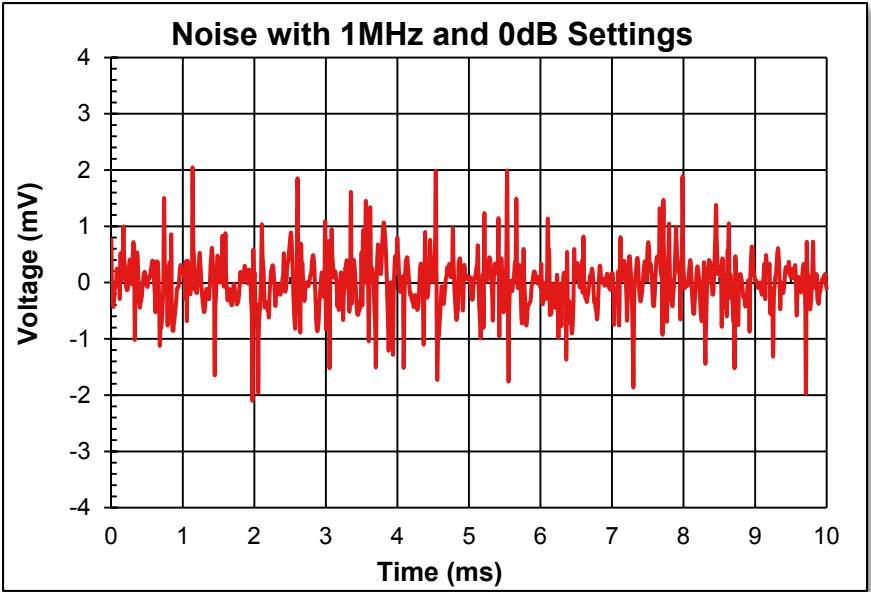


Figure 6 Noise at 1 MHz Bandwidth and 0 and 70 dB Gain

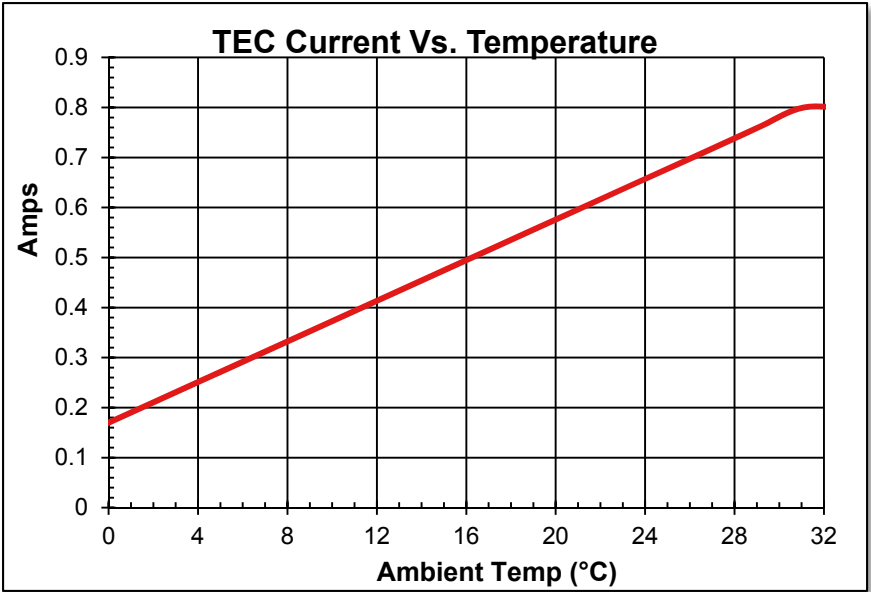


Figure 7 TEC Current vs. Temperature

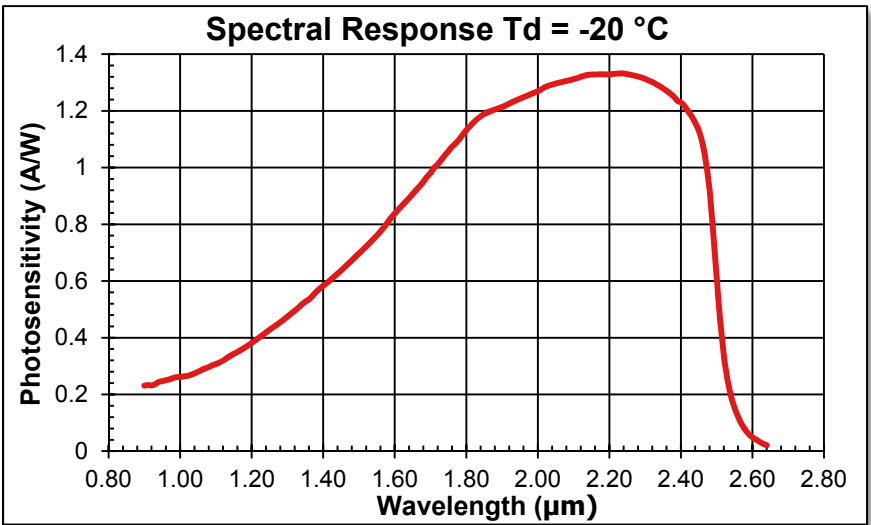
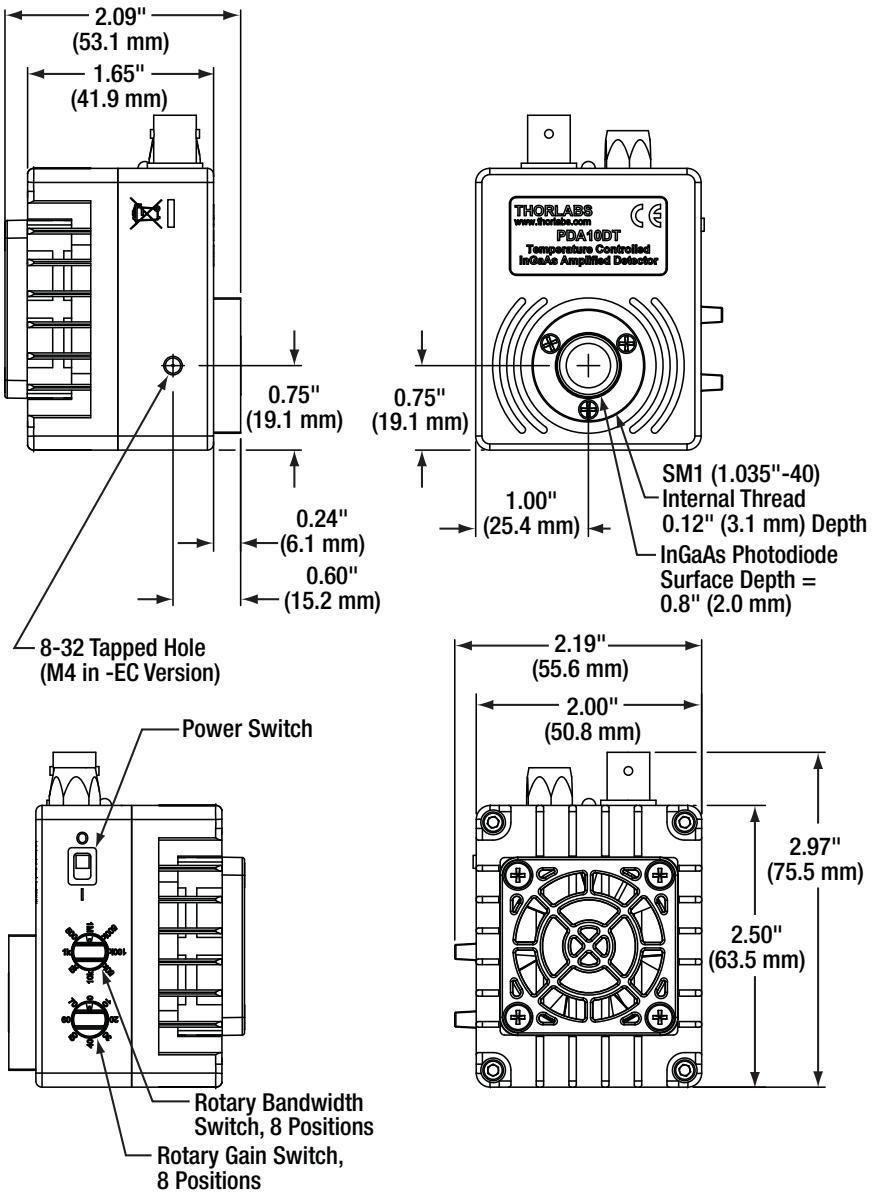


Figure 8 Spectral Response

Chapter 7 Drawings



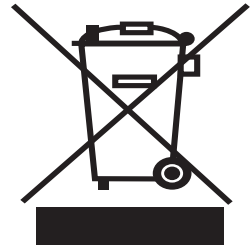
Chapter 8 Troubleshooting

Problem	Suggested Solutions
<p>There is no signal response.</p>	<p>Verify that the power is switched on and all connections are secure.</p>
	<p>Verify the proper terminating resistor is installed if using a Voltage measurement device.</p>
	<p>Verify that the optical signal wavelength is within the specified wavelength range.</p>
	<p>Verify that the optical signal is illuminating the detector active area</p>
	<p>Ensure, not to block, limit airflow to or stop the cooling fan. It will overheat the devise and it will affect its functionality.</p>
<p>Output Voltage will not increase. Detector Output is skewed.</p>	<p>Check to make sure the detector is not saturated. Refer to the Output Voltage spec. in the Specifications table.</p> <p>Install a 1" Lens Tube (SM1L10) to the thread coupler (SM1T1) to baffle any external light sources to see if this improves the response.</p>

Chapter 9 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated



Wheelie Bin Logo

As the WEEE directive applies to self-contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e.g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

9.1. Waste Treatment is Your Own Responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

9.2. Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

Chapter 10 Certificate of Conformance

Konformitätserklärung Declaration of Conformity Déclaration de Conformité

**Thorlabs Inc
56 Sparta Ave.
Newton, NJ
USA**

erklärt in alleiniger Verantwortung, dass das Produkt:
declares under it's own responsibility, that the product:
declare sous notre seule responsabilité, que le produit:

PDA10JT, PDA10DT and PDA10PT

mit den Anforderungen der Normen
fulfills the requirements of the standard
satisfait aux exigences des normes

2006/95 EC	Low Voltage Directive 12.Dec. 2006
EMC 2004/108/EC	Electromagnetic Compatibility Directive
EN 61010-1:2001	Safety of Test and Measurement Equipment
EN 61326-1:2006	EMC of Test and Measurement Equipment
CISPR 11 Edition 4:2003	Conducted Emissions
CISPR 11 Edition 4:2003	Radiated Emissions
IEC 61000-3-2,	Harmonics
IEC 61000-3-3	Voltage Fluctuation and Flicker
IEC 61000-4-2	Electrostatic Discharge
IEC 61000-4-3	Radiated Immunity
IEC 61000-4-4	Electrical Fast Transient/Burst, Power Leads
IEC 61000-4-4	Electrical Fast Transient/Burst, I/O Leads
IEC 61000-4-5	Surge Immunity, Power Leads
IEC 61000-4-6	Conducted Immunity, Power Leads
IEC 61000-4-6	Conducted Immunity, I/O Leads
IEC 61000-4-11	Voltage Dips, Interrupts and Variations

Übereinstimmt und damit den Bedingungen entspricht.
and therefore corresponds to the regulations of the directive.
et répond ainsi aux dispositions de la directive.

Dachau, 10. Mai 2013

Ort und Datum der Ausstellung
Place and date of issue
Lieu et date d'établissement

Name und Unterschrift des Befugten
Name and signature of authorized person
Nom et signature de la personne autorisée

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www.thorlabschina.cn
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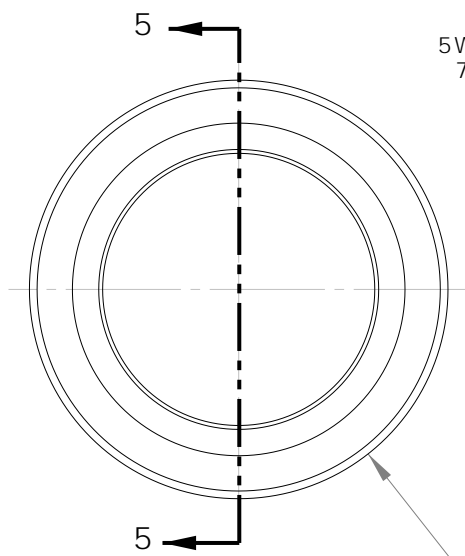
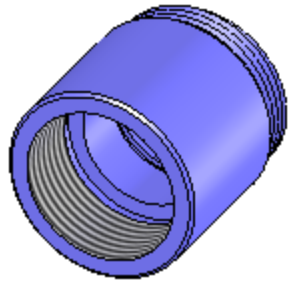


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Allegato C12) Collimatori UV (ruota porta filtri)

Attachment C12) UV Collimators (through filter wheel)

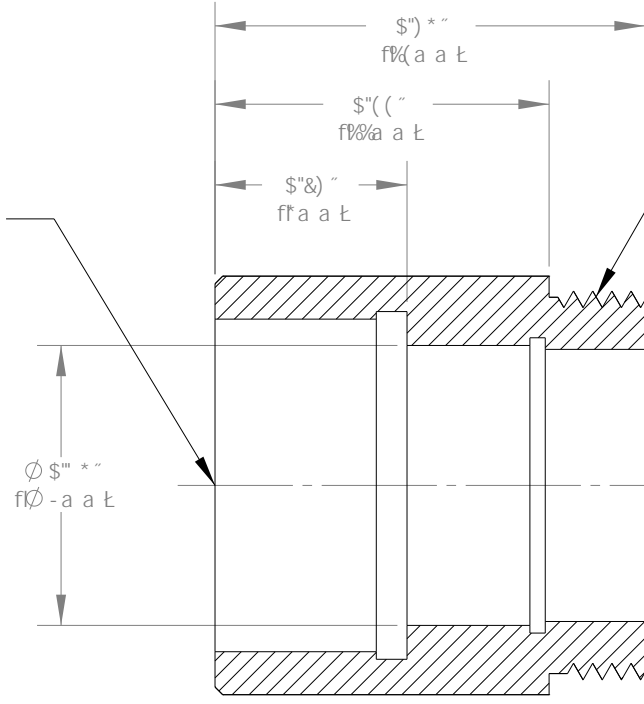
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%	B #H5@K C F? B; '8F5K -B;	>H%\$#++#(\$)
5	B #H5@F9@95G9	>H%\$#/#(\$)



A %\$ (\$) H.fYUX
5WW dHg Ø%a a : JYf
7 c`ja Uhcb'DUW_U[Yg

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Ø (\$) "
fØ % (a a t



G97 HC B '5!5'
G7 5 @ (. %

GHubXUfx 'GA (\$) H.fYUX
fB") ')!(\$t

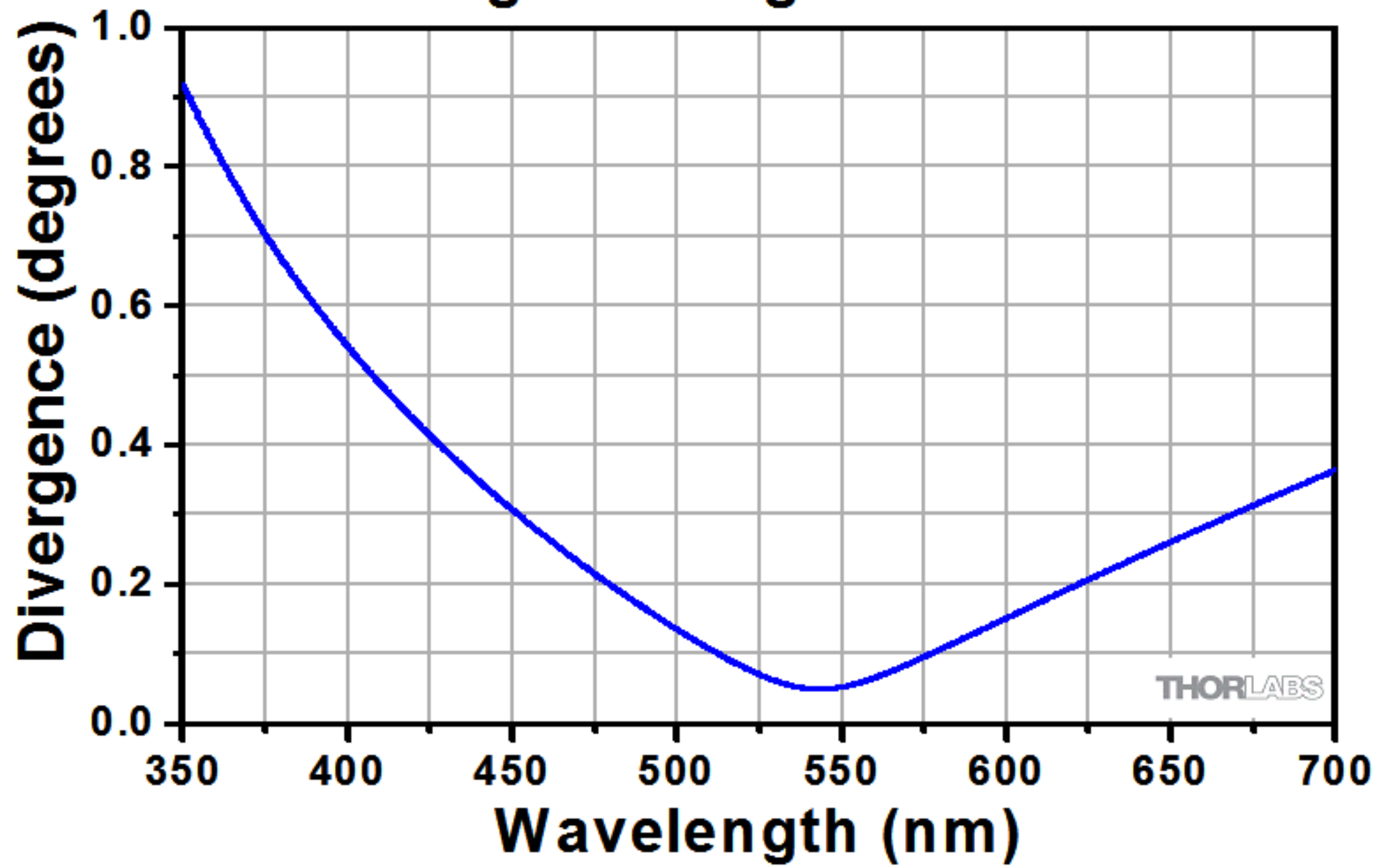
A -I (\$) a a 'H.fYUX
5WW dHg GHubXUfX
- a a '@/bg7Y`g

7 cdmf[\hî A&\$\$) žHc fUVgž bW

HC@F5B79G	B5A 9	85H9
1 B@9GC H:9FK @9 GD97 ≠98.	8F5K B	>>H \$* #- #&\$S)
8-A 9BGC BG5F9-B 'B7 <9G	9B: '5DDF"	>>H %\$#++#&\$S)
@B95F HC@F5B79G'	A:: '5DDF"	LLL 11#1#111
...HK C D@579897-A 5@ ±\$%\$	DFC DF-96FM5B87CB: @9BH5@	
...HF99D@579897-A 5@ ±\$%\$S)	H:9 B: CFA 5HC B 7 C B H5 B98 -B H:G	
5B: 1 @F. ±' \$f"	8F5K -B: 'G H:9GC @DFC D9F HMC:	
GI F: 579: -B G<." &A -7FC -B7 <9G	H:C F@56Gz-B7 "'5BMF9DFC 81 7 HC B	
D5F5 @9@CA. '\$\$S&	-B D5FHC F 5G5 K <C @K H:C I H	
: @HB 9CG '\$\$S&	H:9K F #H9 D9FA @GC B C:	
GF 5≠ <HB 9CG '\$\$S&	H:C F@56Gz-B7 "'GDFC <-6+98"	
7 C B7 9B HF -7 HM '\$\$S&		
D9F D9B 8-71 @5F #M '\$\$S&		
H:F 958.7 @GG&: #		

Hk C F @56G-B7 "		DC '6CL' **
		B9K HC B B >
H#@. 7 c`ja Uhcb'H VY '@/bg5XUdHyf		
A 5H9F 5@	GG' '\$	G#9 F9J "
		5 %
G7 5 @. &%	G< 99H% C: %	
8K ; "'BC"	D5FHBC "	
% \$, \$!9\$%	58%/\$-:	

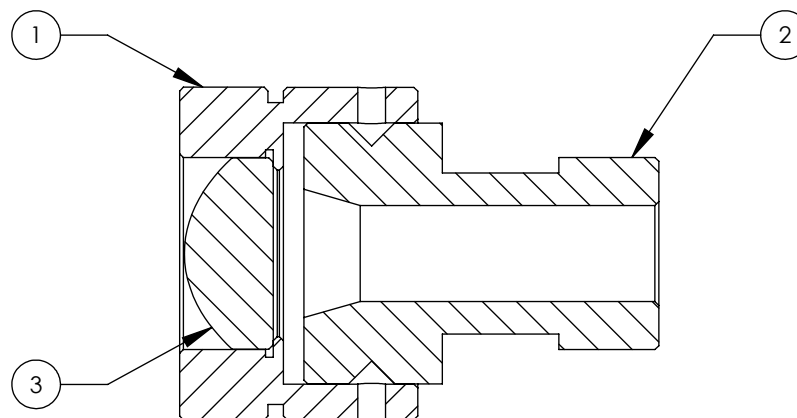
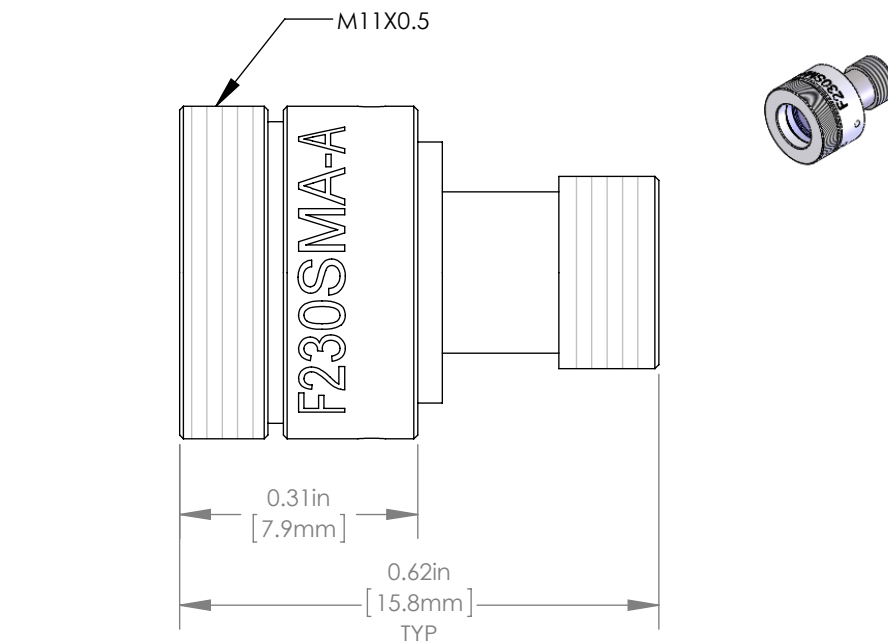
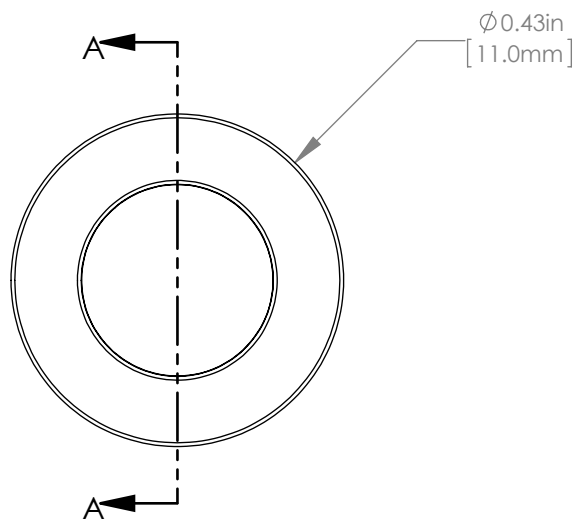
Full-Angle Divergence: F230-A



	ITEM	MATERIAL
①	HOUSING	303 STAINLESS STEEL
②	FC/SMA PLUG ADAPTER	303 STAINLESS STEEL
③	∅7.2mm, f=4.34mm LENS	MOLDED ASPHERE

SPECIFICATIONS

DESIGN WAVELENGTH	543 nm
DESIGN MFD	3.67 μm
OUTPUT 1/e ² BEAM DIAMETER	0.80 mm
FULL ANGLE BEAM DIVERGENCE	0.05° ^{+0.01} / _{-0.00}
AR COATING	Ravg<0.5% FROM 350-700nm



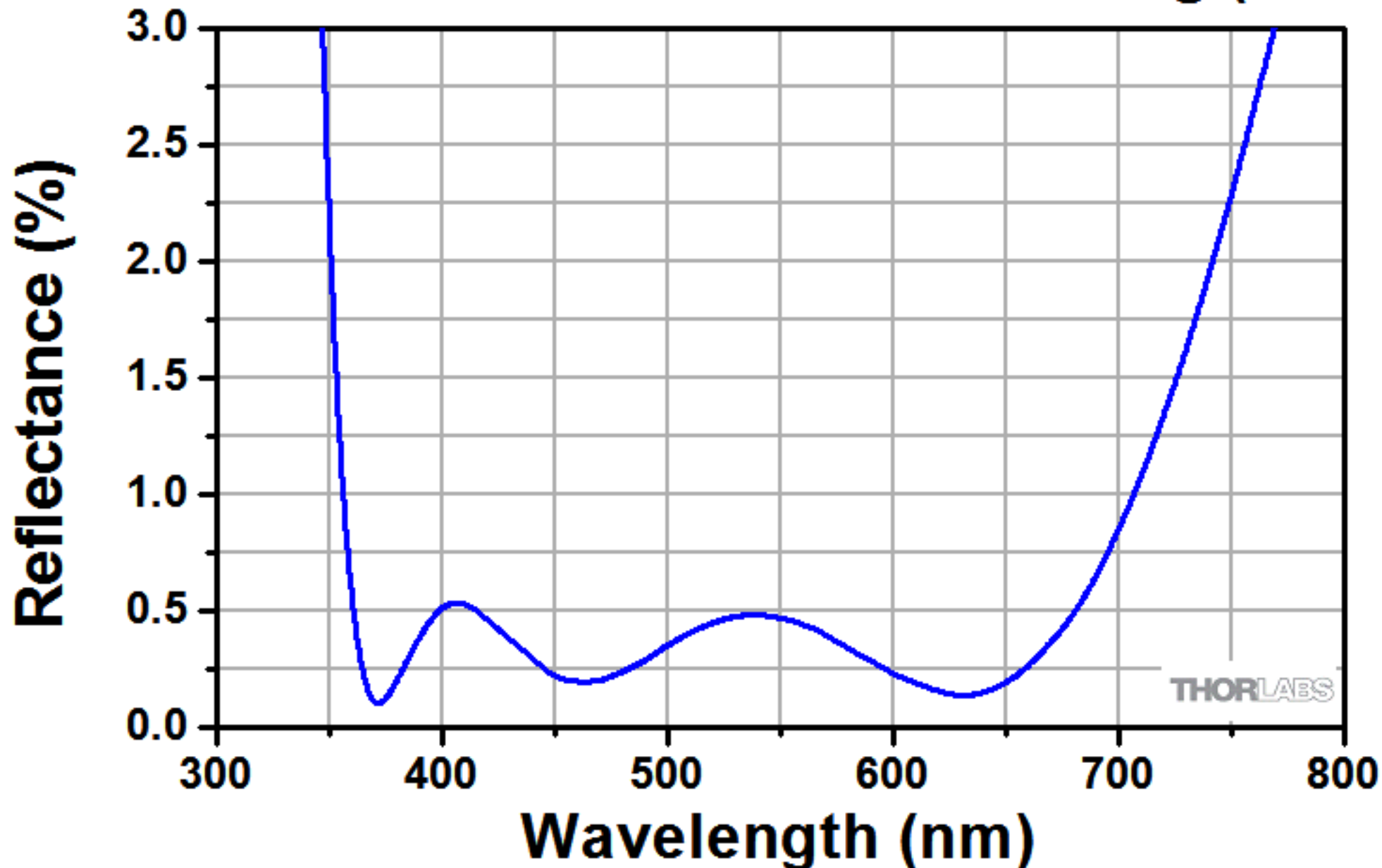
SECTION A-A

THORLABS FIBER COLLIMATION PACKAGES ARE DESIGNED TO COLLIMATE A LASER BEAM PROPAGATING OUT THE END OF AN OPTICAL FIBER. EACH COLLIMATION PACKAGE IS FACTORY ALIGNED SO THAT THE BEST POSSIBLE DIVERGENCE IS ACHIEVED.

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DRAWING PROJECTION			THORLABS www.thorlabs.com	
	NAME	DATE	λ=543nm SMA COLLIMATION PACKAGE, NA=0.57 f=4.34mm	
DRAWN	ST	16/OCT/14		
APPROVAL	NE	05/DEC/14		
COPYRIGHT © 2014 BY THORLABS			MATERIAL	REV D
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS			ITEM #	APPROX WEIGHT
			F230SMA-A	5.87 g
			SEE TABLE	

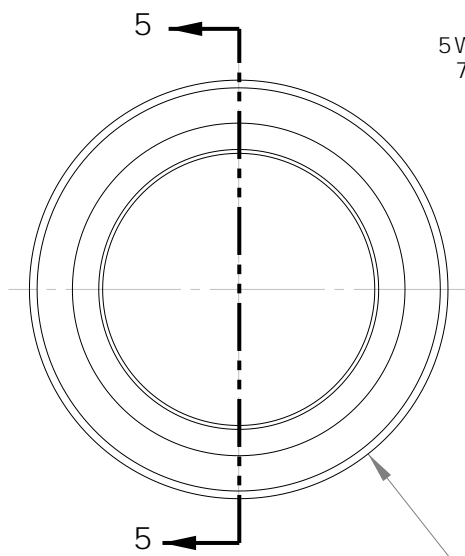
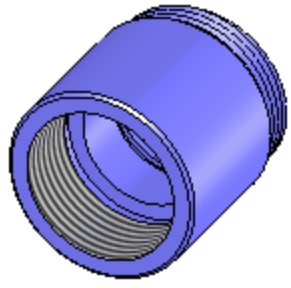
-A Broadband Antireflection Coating (8° AOI)



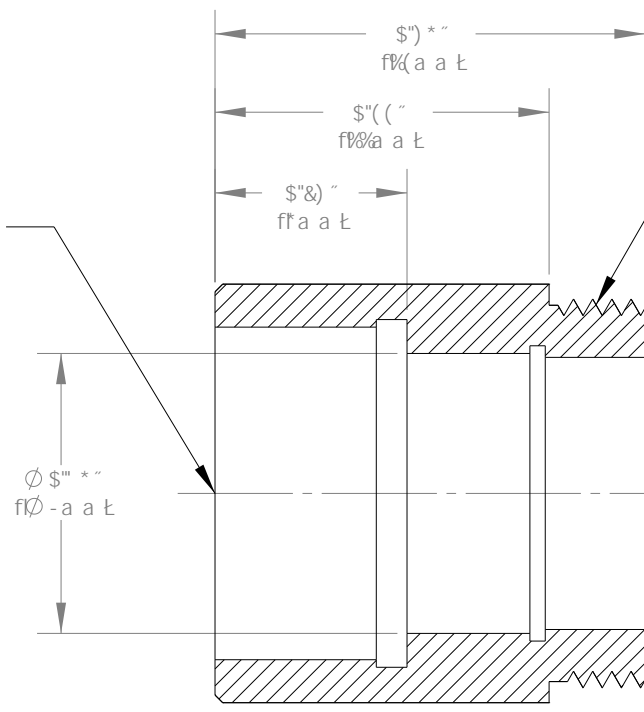
Allegato C13) Collimatori IR (ruota porta filtri)

Attachment C13) IR Collimators (through filter wheel).

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%	B #H5@K C F? B; '8F5K -B;	>H%\$##+\$)
5	B #H5@F9@95G9	>H%\$#/#\$)



A %\$ "\$) H.fYUX
5WW dHg Ø %\$a a : JYf
7 c`ja Uhçb'DUW_U[Yg



GtUbXUfx 'GA \$) H.fYUX
fB\$)')!(\$t

A -I \$)" a a H.fYUX
5WW dHgGtUbXUfx
- a a @'bg7Y`g

Ø \$)" *"
fØ -a a t

G97 HC B '5!5'
G7 5 @ (. %

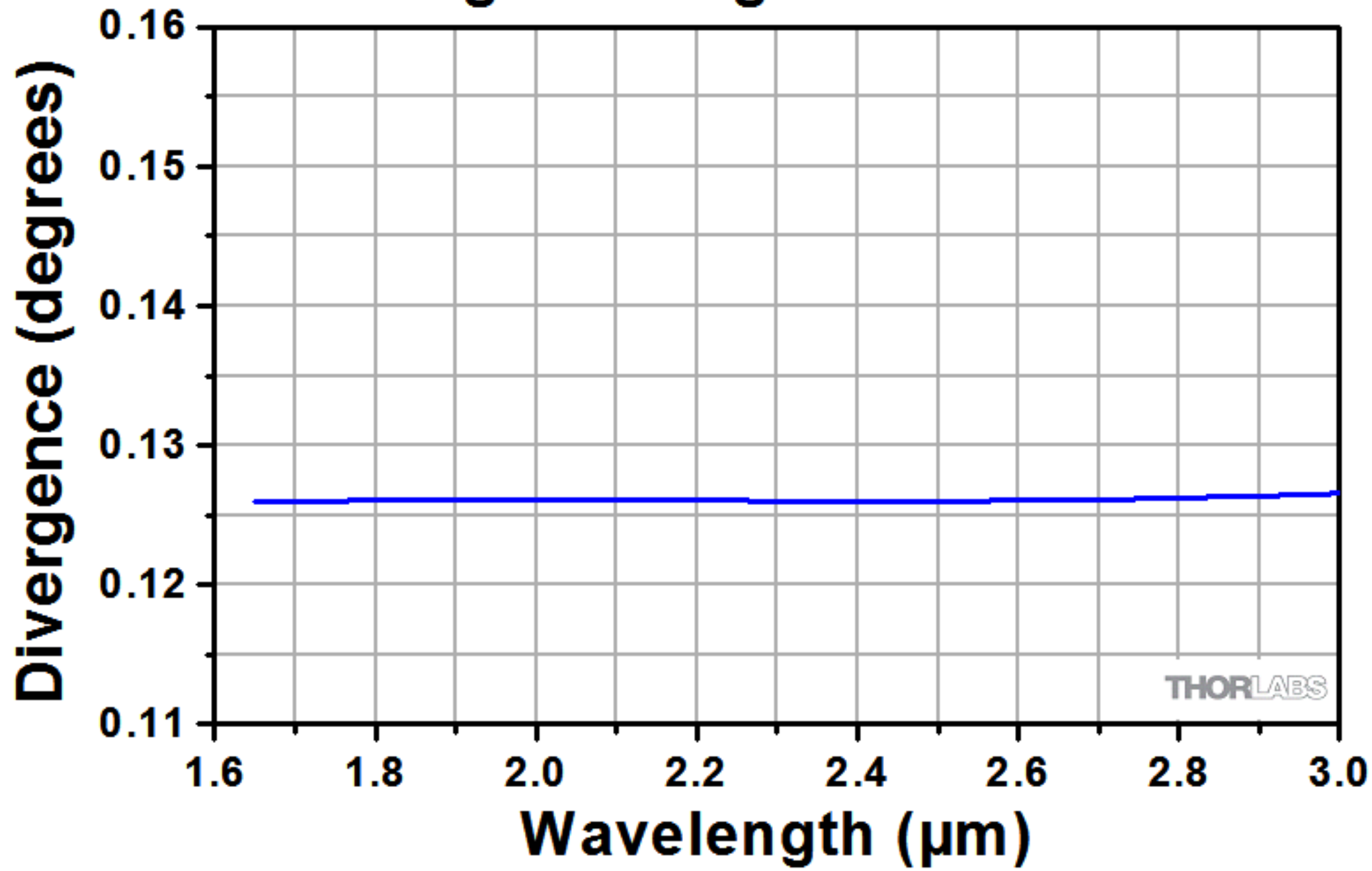
Ø \$)" "
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7 cdmf[\hî A&\$\$) žHçfUVgž bW

HC@F5B79G	B5A 9	85H9
1 B@9GC H:9FK @9 GD97 ≠98.	8F5K B	>>H \$* #- #&\$)
8-A 9BGC BG5F9-B 'B7 <9G	9B: '5DDF"	>>H %\$##&\$)
@B95F HC@F5B79G	A:: '5DDF"	LLL 11#1#111
...HK C D@579897-A 5@ ±\$%\$	DFC DF-96FM5B87CB: -B9BH5@	
...H:F99D@579897-A 5@ ±\$%\$)	H:9 B: CFA 5HC B 7 C B H5-B 98 -B H:G	
5B: 1 @F. ±' \$f"	8F5K -B: 'G H:9GC @DFC D9F HMC:	
GI F: 579: -B-G<." &A -7FC -B7 <9G	H:C F@56Gz-B7 "'5BMF9DFC 81 7 HC B	
D5F5 @9@CA. '\$\$\$&	-B D5FHC F 5G5 K <C @K H:C I H	
: @5B 9CG '\$\$\$&	H:9K F #H9 D9FA @GC B C:	
GF 5≠ <HB 9CG '\$\$\$&	H:C F@56Gz-B7 "'GDFC <-6+98"	
7 C B7 9B HF -7 HM '\$\$\$&		
D9F D9B 8-71 @5F #M '\$\$\$&		
H:F 958. 7 @GG&: #		

Hk C F @56Gz-B7 "		DC '6CL' **
		B9K HC B B>
H#@. 7 c`ja Uhçb'H VY '@'bg5XUdHyf		
A 5H9F 5@	GG' '\$	G#9 F9J "
		5 %
G7 5 @. &%		G<99H% C: %
8K ; "'BC"	D5FHBC "	
% \$, \$!9\$%	58%\$-:	

Full-Angle Divergence: F028-2000

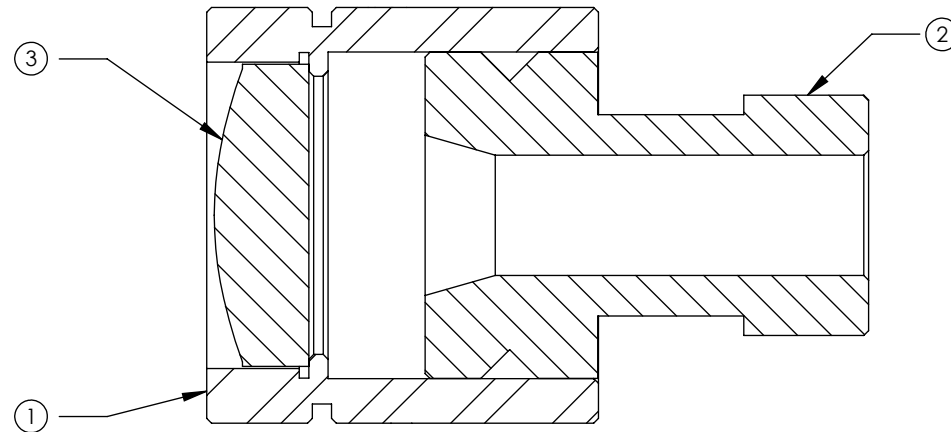
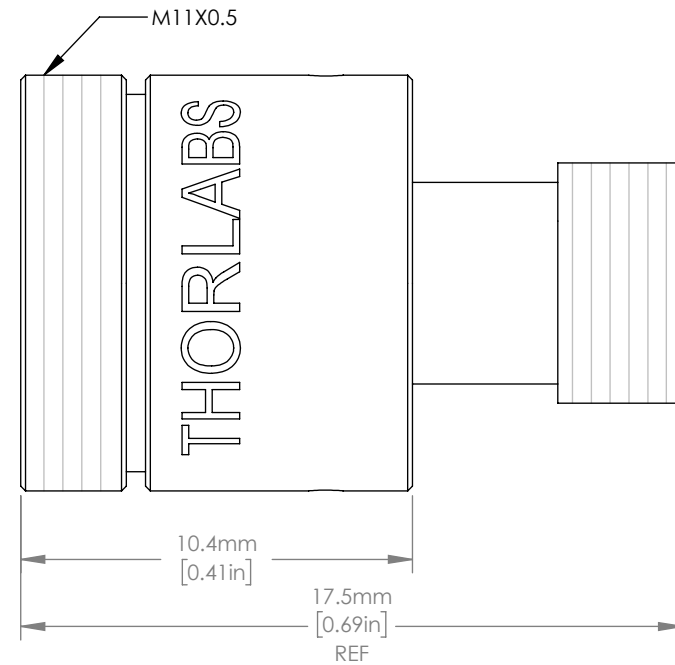
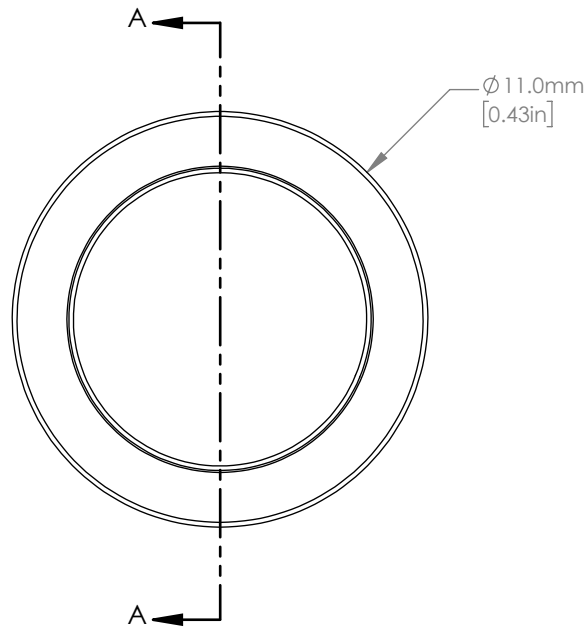


	ITEM	MATERIAL
①	HOUSING	303 STAINLESS STEEL
②	SMA PLUG ADAPTER	303 STAINLESS STEEL
③	Ø 8.0mm, f=5.91mm LENS	BD2-CHALCOGENIDE



SPECIFICATIONS

DESIGN WAVELENGTH	2µm
DESIGN MFD	13.0µm
OUTPUT 1/e ² BEAM DIAMETER	1.2mm ±0.01mm
FULL ANGLE BEAM DIVERGENCE	0.13 +0.01/-0.00°
AR COATING	Ravg<1.0% FROM 1.8-3µm



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DRAWING
PROJECTION



	NAME	DATE
DRAWN	KMR	28/SEP/16
APPROVAL	BW	20/DEC/16

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λ=2000nm SMA COLLIMATION
PACKAGE, NA=0.56, f=5.91mm

MATERIAL

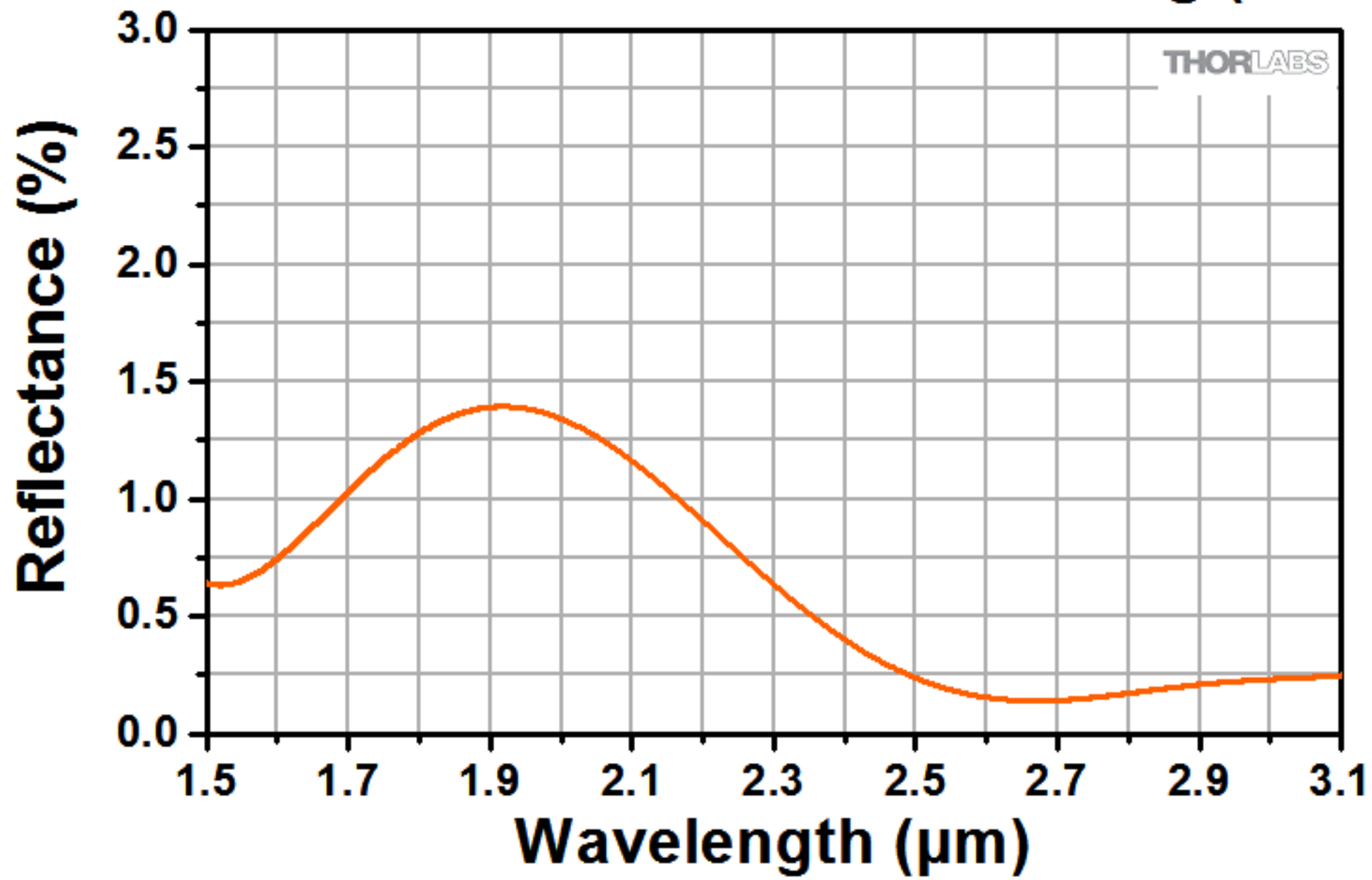
SEE TABLE

REV
D

ITEM #
F028SMA-2000

APPROX WEIGHT
0.03 kg

-D Broadband Antireflection Coating (8° AOI)



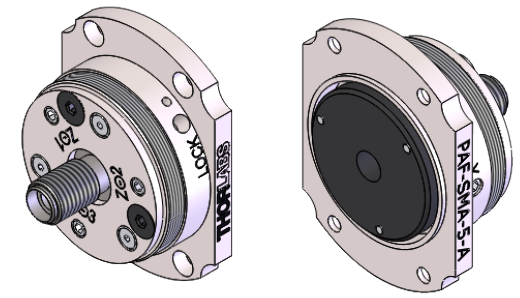
Allegato C14) Collimatori UV (fibra-porta filtri-sensore)

Attachment C14) UV Collimators (fiber-filters holder-detector)

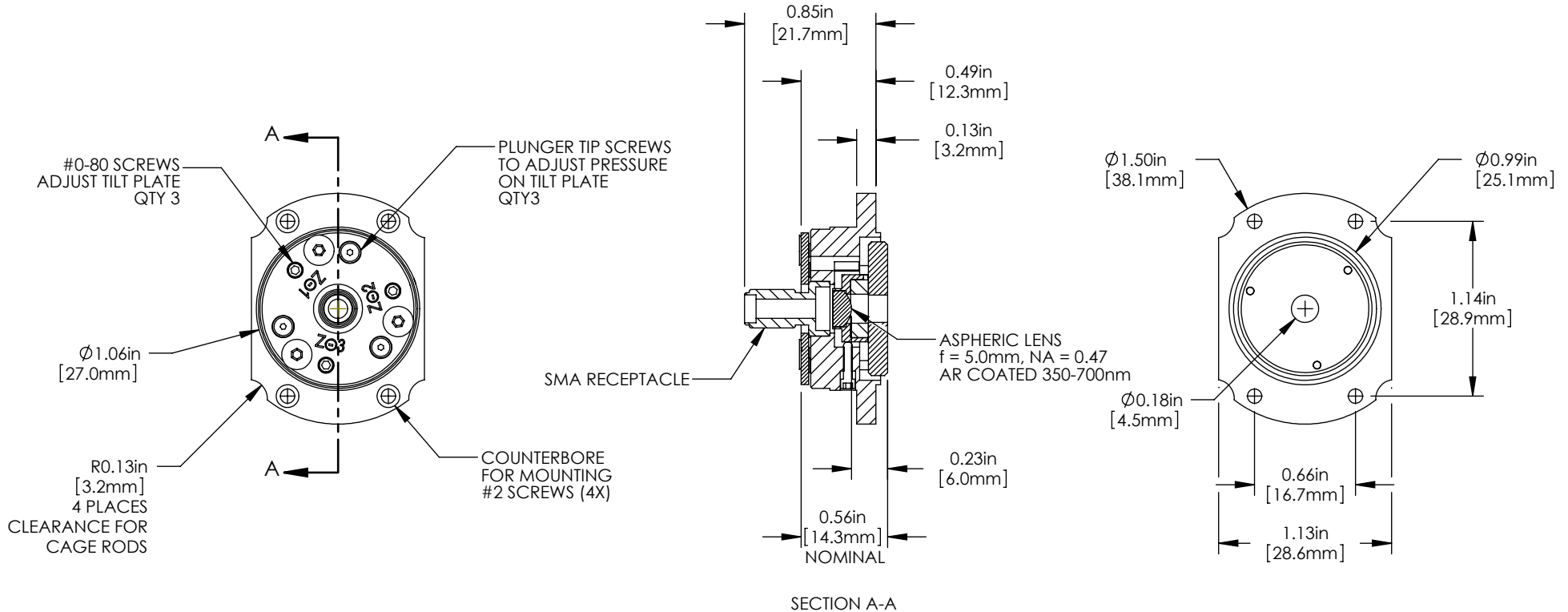
SPECIFICATIONS

INPUT MFD FROM 460HP FIBER*	OUTPUT $1/e^2$ WAIST DIAMETER*	MAX WAIST DISTANCE*	DIVERGENCE*	LENS CLEAR APERTURE
3.5 μ m	0.75 mm	499 mm	0.761 mrad	4.9 mm

*CALCULATED USING 1550nm WAVELENGTH



ISOMETRIC VIEW
SCALE 1:1



NOTES:
EACH FIBERPORT IS FACTORY ALIGNED FOR COLLIMATION AT 488nm

INCLUDED BUT NOT SHOWN:

- DUST CAP
- 0.035 HEX KEY
- 0.050 HEX KEY
- 0-80 LOCKING SCREW

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DRAWING PROJECTION					
		www.thorlabs.com		FIBERPORT, SMA, $f=4.6$ mm, 350 - 700 nm, $\phi 0.75$ mm WAIST	
DRAWN	CB	DATE	21 SEP 10	MATERIAL	N/A
APPROVAL	BAG	DATE	31 OCT 16	REV	D
COPYRIGHT © 2016 BY THORLABS					
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS				ITEM #	APPROX WEIGHT
				PAF-SMA-5-A	0.09kg



PAF Series
Aspheric and Achromatic
FiberPort Collimators with
FC/PC, FC/APC, or SMA
Adapters

User Guide



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Chapter 1 Description

1.1. Mechanisms of the FiberPort

The FiberPort is a six-degree-of-freedom fiber collimator and coupler (5 axes, plus rotation). It uses a movable lens as the alignment mechanism while holding the fiber stationary. This provides an extremely stable and repeatable platform for coupling and collimating. All adjustments are coupled.

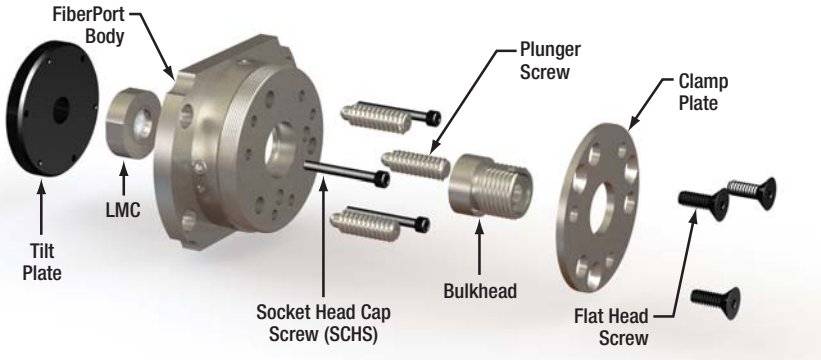


Figure 1 Components of a FiberPort

The FiberPort consists of a body, a Magnetic Lens Cell (LMC) adhered to a tilt plate, and a bulkhead with fiber connector. The bulkhead is locked onto the FiberPort body by three flat head screws and the clamp plate. By loosening the flat head screws, the fiber bulkhead can be rotated freely.

1.1.1. Z/q/j Adjustment

The LMC adheres to the tilt plate, which can be adjusted in Z/q/j (Axial, Tip, Tilt) using the three socket head cap screws (SCHS). The plunger screws provide counterforce against the SCHS. The Z (optical axis) translation range is ± 0.4 mm for a given position of the plunger screws. The plunger screws can translate the positive extreme of the travel range in the Z direction over a distance of 2 mm.

1.1.2. X-Y Adjustment

Additionally, the LMC can be translated in X-Y using the setscrews in the side of the fiberport body. The LMC rests on a leaf spring, and the X-Y screws push the cell against the leaf spring. A third setscrew behind the leaf spring can be used for locking. The travel range of the aspheric lens in the X and Y directions is ± 0.7 mm but when the FiberPort is used in a standard collimation/coupling application only a small portion of this translation range is used.

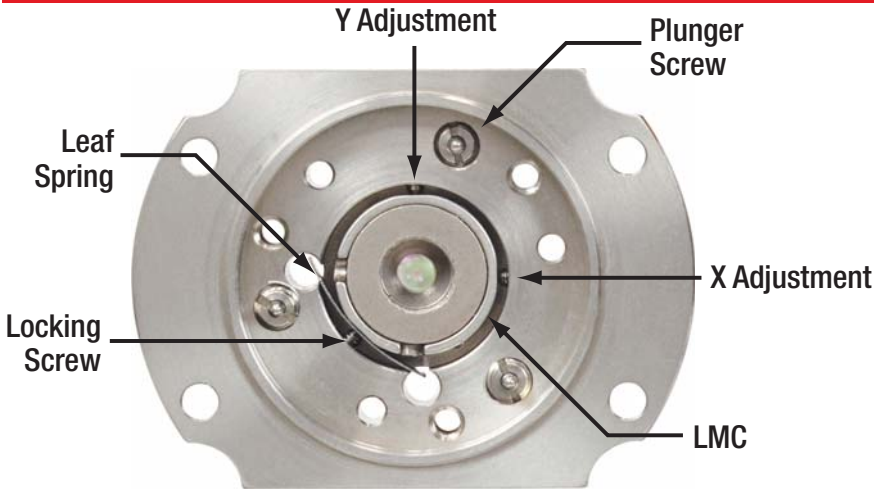


Figure 2 FiberPort Internal View: The Tilt Plate has Been Removed to Show the Lens Cell and Leaf Spring

The X-Y lens adjustment screws are located on the outer diameter of the FiberPort body at the 3 o'clock and the 12 o'clock positions. The three plunger screws provide counterforce for the tilt plate. The three socket head cap screws (SHCS) provide the Z/q/j adjustments for the FiberPort. The three SHCS and the X-Y screws are the only screws that are normally used in the alignment of the FiberPort. However, the plunge screws can be used to adjust the tension on the tilt plate if needed. Also, the three flat head screws on the face of the FiberPort hold the clamp plate and bulkhead in place. By loosening these screws, the bulkhead can be rotated a full 360° and secured at any angle for PM applications. This is a coarse adjustment, however.

The locking screw is located on the outer diameter of the FiberPort body at the 7:30 position. The locking screw is not installed when the FiberPort is shipped but is included in the package. The locking screw is only used after the FiberPort is aligned.

NOTE: Locking the FiberPort is not necessary in most applications and can affect coupling.

1.2. Location of Screws on the FiberPort

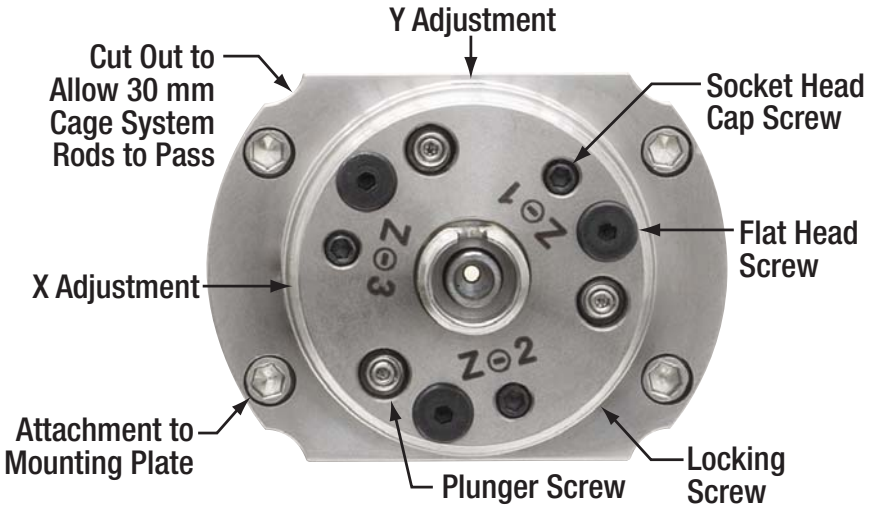


Figure 3 Location of Screws on the FiberPort

Part	Screw Size to Use	Head Size (Hex)
Mounting Plate Attachment Screws	2-56	5/64"
X, Y, and Locking Set Screws	0-80	0.050"
Z (Tip & Tilt) Socket Head Cap Screws	0-80	0.050"
Flat Head Screws	2-56	0.050"
Plunger Screws	6-32	0.035"

Chapter 2 Specifications

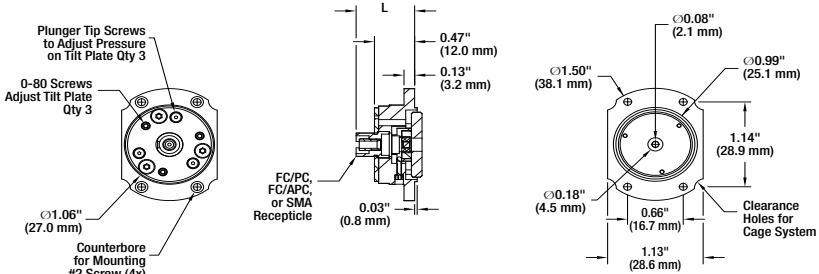


Figure 4 Schematic Diagram of the FiberPort

2.1. Achromatic FiberPorts

We offer achromatic FiberPorts as an alternative to our standard aspheric models. They perform similarly to our short focal length aspheric FiberPorts, but with a very small focal length shift over a broad wavelength range.

Item#	EFL (mm)	Input MFD ¹ (µm)	Output Waist Dia. (1/e ²) (mm)	Max Waist Dist. ² (mm)	Diverg. (mrad)	Focal Length Shift ³ (µm)	Lens Characteristics			Length L (in/mm)
							CA ⁴ (mm)	NA	AR Range ⁵ (nm)	
PAFA-X-4-A	4.0	3.5	0.65	378	0.875	8.3	1.8	0.22	400 - 700	0.69/17.5
PAFA-X-4-B	4.0	5.0	0.87	350	1.250	6.9	1.8	0.22	600 - 1050	0.69/17.5
PAFA-X-4-C	4.0	10.4	0.76	150	2.600	14.8	1.8	0.22	1050 - 1620	0.69/17.5

- 1) Mode-Field Diameter. This spec was calculated using the following equipment:
 PAFA-X-4-A: 460HP at 450 nm
 PAFA-X-4-B: 780HP at 850 nm
 PAFA-X-4-C: SMF-28e+ at 1550 nm
- 2) Maximum Waist Distance: The max distance from the lens a Gaussian beam's waist can be placed.
- 3) Focal length shift is defined over the entire AR coating range.
- 4) Clear Aperture
- 5) Wavelength of the Antireflection Coating

2.2. Aspheric FiberPorts

Our standard aspheric lens FiberPorts are available with a variety of focal length and coating options. The first table details all of our SMA-compatible FiberPorts. PAF-X-2, -4, -5, and -7 FiberPorts in the second table have a straight FC bulkhead which will work with FC/PC and FC/APC connectors. The PAF-X-11, -15, and -18 in the last table come with either FC/PC- or FC/APC-compatible bulkheads.

2.2.1. All Focal Lengths, SMA-Compatible

Item#	EFL (mm)	Input MFD ¹ (μm)	Output Waist Dia. (1/e ²) (mm)	Max Waist Dist. ² (mm)	Diverg. (mrad)	Lens Characteristics			Length L (in/mm)
						CA ³ (mm)	NA	AR Range (nm) ⁴	
PAF-SMA-4-E	4.0	14.47	1.23	169	3.617	5.0	0.56	2000 - 5000	0.85/21.7
PAF-SMA-5-A	4.6	3.5	0.75	499	0.761	4.9	0.47	350 - 700	0.85/21.7
PAF-SMA-5-B	4.6	5.0	1.00	463	1.087	4.9	0.47	600 - 1050	0.85/21.7
PAF-SMA-5-C	4.6	10.4	0.87	198	2.261	4.9	0.47	1050 - 1620	0.85/21.7
PAF-SMA-5-D	4.6	13	0.90	164	2.826	4.9	0.47	1800 - 2400	0.85/21.7
PAF-SMA-7-A	7.5	3.5	1.23	1323	0.467	4.4	0.29	350 - 700	0.85/21.7
PAF-SMA-7-B	7.5	5.0	1.62	1125	0.667	4.4	0.29	600 - 1050	0.85/21.7
PAF-SMA-7-C	7.5	10.4	1.42	521	1.387	4.4	0.29	1050 - 1620	0.85/21.7
PAF-SMA-11-A	11.0	3.5	1.80	2841	0.318	4.4	0.20	350 - 700	1.04/26.3
PAF-SMA-11-B	11.0	5.0	2.38	2630	0.455	4.4	0.20	600 - 1050	1.04/26.3
PAF-SMA-11-C	11.0	10.4	2.09	1115	0.945	4.4	0.20	1050 - 1620	1.04/26.3
PAF-SMA-11-D	11.0	13	2.15	923	1.182	4.4	0.20	1800 - 2400	1.04/26.3
PAF-SMA-11-E	11.0	14.47	3.39	1258	1.315	4.0	0.18	2000 - 5000	1.04/26.3

1) Mode Field Diameter. Calculated using the following equipment: -A: 460HP at 450 nm, -B: 780HP at 850 nm, -C: SMF-28e+ at 1550 nm, -D: SM2000 at 2000 nm, -E: ZrF₄ at 3.39 μm

2) Maximum Waist Distance: The max distance from the lens a Gaussian beam's waist can be placed.

3) Clear Aperture

4) Wavelength Range of the Antireflection Coating

2.2.2. Short Focal Length, FC/PC and FC/APC Compatible

Item#	EFL (mm)	Input MFD ¹ (μm)	Output Waist Dia. (1/e ²) (mm)	Max Waist Dist. ² (mm)	Diverg. (mrad)	Lens Characteristics			Length L (in/mm)
						CA ³ (mm)	NA	AR Range ⁴ (nm)	
PAF-X-2-A	2.0	3.5	0.33	96	1.750	2.0	0.50	350 - 700	0.65/16.6
PAF-X-2-B	2.0	5.0	0.43	89	2.500	2.0	0.50	600 - 1050	0.65/16.6
PAF-X-2-C	2.0	10.4	0.38	38	5.200	2.0	0.50	1050 - 1620	0.65/16.6
PAF-X-4-E	4.0	14.47	1.23	169	3.617	5.0	0.56	2000 - 5000	0.69/17.5
PAF-X-5-A	4.6	3.5	0.75	499	0.761	4.9	0.47	350 - 700	0.69/17.5
PAF-X-5-B	4.6	5.0	1.00	463	1.087	4.9	0.47	600 - 1050	0.69/17.5
PAF-X-5-C	4.6	10.4	0.87	198	2.261	4.9	0.47	1050 - 1600	0.69/17.5
PAF-X-5-D	4.6	13	0.90	164	2.826	4.9	0.47	1800 - 2400	0.69/17.5
PAF-X-7-A	7.5	3.5	1.23	1323	0.467	4.4	0.29	350 - 700	0.69/17.5
PAF-X-7-B	7.5	5.0	1.62	1225	0.667	4.4	0.29	600 - 1050	0.69/17.5
PAF-X-7-C	7.5	10.4	1.42	521	1.387	4.4	0.29	1050 - 1620	0.69/17.5

1) Mode Field Diameter. Calculated using the following equipment: -A: 460HP at 450 nm, -B: 780HP at 850 nm, -C: SMF-28e+ at 1550 nm, -D: SM2000 at 2000 nm, -E: ZrF₄ at 3.39 μm

2) Maximum Waist Distance: The max distance from the lens a Gaussian beam's waist can be placed.

3) Clear Aperture

4) Wavelength Range of the Antireflection Coating

2.2.3. Long Focal Length, FC/APC or FC/PC Compatible

Item#	EFL (mm)	Input MFD ¹ (μm)	Output Waist Dia. (1/e ²) (mm)	Max Waist Dist. ² (mm)	Diverg. (mrad)	Lens Characteristics			Length L (in/mm)
						CA ³ (mm)	NA	AR Range (nm) ⁴	
FC/APC Compatible									
PAF-X-11-A	11.0	3.5	1.80	2841	0.318	4.4	0.20	350 - 700	0.87/22.0
PAF-X-11-B	11.0	5.0	2.38	2630	0.455	4.4	0.20	600 - 1050	0.87/22.0
PAF-X-11-C	11.0	10.4	2.09	1115	0.945	4.4	0.20	1050 - 1620	0.87/22.0
PAF-X-11-D	11.0	13	2.15	923	1.182	4.4	0.20	1800 - 2400	0.87/22.0
PAF-X-15-A	15.4	3.5	2.52	5562	0.227	5.0	0.16	350 - 700	0.87/22.0
PAF-X-15-B	15.4	5.0	3.33	5149	0.325	5.0	0.16	600 - 1050	0.87/22.0
PAF-X-15-C	15.4	10.4	2.92	2179	0.675	5.0	0.16	1050 - 1620	0.87/22.0
PAF-X-15-D	15.4	13	3.02	1802	0.844	5.0	0.16	1800 - 2400	0.87/22.0
PAF-X-18-A	18.4	3.5	3.01	7936	0.190	5.5	0.15	350 - 700	0.87/22.0
PAF-X-18-B	18.4	5.0	3.98	7347	0.272	5.5	0.15	600 - 1050	0.87/22.0
PAF-X-18-C	18.4	10.4	3.49	3107	0.565	5.5	0.15	1050 - 1620	0.87/22.0
PAF-X-18-D	18.4	13	3.60	2569	0.707	5.5	0.15	1800 - 2400	0.87/22.0
FC/PC Compatible									
PAF-X-11-PC-A	11.0	3.5	1.80	2841	0.318	4.4	0.20	350 - 700	0.87/22.0
PAF-X-11-PC-B	11.0	5.0	2.38	2630	0.455	4.4	0.20	600 - 1050	0.87/22.0
PAF-X-11-PC-C	11.0	10.4	2.09	1115	0.945	4.4	0.20	1050 - 1620	0.87/22.0
PAF-X-11-PC-D	11.0	13	2.15	923	1.182	4.4	0.20	1800 - 2400	0.87/22.0
PAF-X-11-PC-E	11.0	14.47	3.39	1258	1.315	4.0	0.18	2000 - 5000	0.87/22.0
PAF-X-15-PC-A	15.4	3.5	2.52	5562	0.227	5.0	0.16	350 - 700	0.87/22.0
PAF-X-15-PC-B	15.4	5.0	3.33	5149	0.325	5.0	0.16	600 - 1050	0.87/22.0
PAF-X-15-PC-C	15.4	10.4	2.92	2179	0.675	5.0	0.16	1050 - 1620	0.87/22.0
PAF-X-15-PC-D	15.4	13	3.02	1802	0.844	5.0	0.16	1800 - 2400	0.87/22.0
PAF-X-18-PC-A	18.4	3.5	3.01	8936	0.190	5.5	0.15	350 - 700	0.69/17.5
PAF-X-18-PC-B	18.4	5.0	3.98	7347	0.272	5.5	0.15	600 - 1050	0.69/17.5
PAF-X-18-PC-C	18.4	10.4	3.49	3107	0.565	5.5	0.15	1050 - 1620	0.69/17.5
PAF-X-18-PC-D	18.4	13	3.60	2569	0.707	5.5	0.15	1800 - 2400	0.69/17.5

1) Mode Field Diameter. Calculated using the following equipment: -A: 460HP at 450 nm, -B: 780HP at 850 nm, -C: SMF-28e+ at 1550 nm, -D: SM2000 at 2000 nm, -E: ZrF₄ at 3.39 μm

2) Maximum Waist Distance: The max distance from the lens a Gaussian beam's waist can be placed

3) Clear Aperture

4) Wavelength Range of the Antireflection Coating

2.3. Lens Materials

Item #	Material
PAF-xxx-2-x	ECO-550
PAFA-X-4-A*	N-SK16/N-LASF9
PAFA-X-4-B*	N-LAK22/N-SF6HT
PAFA-X-4-C*	N-SF66/N-LASF41
PAF-xxx-4-E	Black Diamond-2
PAF-xxx-5-x	H-LAK54
PAF-xxx-7-x	H-LAK54
PAF-xxx-11-A	H-LAK54
PAF-xxx-11-B	H-LAK54
PAF-xxx-11-C	H-LAK54
PAF-xxx-11-D	H-LAK54
PAF-xxx-11-E	Black Diamond-2
PAF-xxx-15-x	ECO-550
PAF-xxx-18-x	ECO-550

*Achromatic doublet lenses. All other FiberPorts use aspheric lenses.

Chapter 3 FiberPort Guide

3.1. Selection Table

The table below can be used as a selection guide to determine which FiberPort would best suit your needs.

Item#	EFL (mm)	Coupling Input Beam Diameter (mm)	Collimated Output Beam Diameter (mm)	Best Collimation Distance at	Connector Compatibility
PAF-X-2- λ	2.0	0.3 – 0.8	0.33	1 – 20 cm	All FC
PAF-X-5- λ	4.6	0.8 – 1.4	0.75	10 cm & Beyond	All FC
PAF-X-7- λ	7.5	1.2 – 2.0	1.4	20 cm & Beyond	All FC
PAF-X-11- λ	11.0	1.9 – 3.0	2.1	20 cm & Beyond	FC/APC
PAF-X-11- λ -PC	11.0	1.9 – 3.0	2.1	20 cm & Beyond	FC/PC
PAF-X-15- λ	15.4	2.8 – 4.0	2.9	30 cm & Beyond	FC/APC
PAF-X-15- λ -PC	15.4	2.8 – 4.0	2.9	30 cm & Beyond	FC/PC
PAF-X-18- λ	18.0	3.4 – 4.7	3.5	30 cm & Beyond	FC/APC
PAF-X-18- λ -PC	18.0	3.4 – 4.7	3.5	30 cm & Beyond	FC/PC

Note: PAF-X-2, -5, and -7 FiberPorts have a straight FC bulkhead which will work with FC/PC and FC/APC connectors. The PAF-X-11, -15, and -18 come with either PC or APC compatible bulkheads. Please specify which type of connector you will be using when ordering a PAF-X-11 through -18 FiberPort.

3.2. Selection Example

The example presented here details the steps needed to ensure proper selection of a FiberPort to match the requirements of a particular fiber. For specific recommendations, please contact TechSupport@thorlabs.com.

- Fiber: P1-630A-FC-2
- Collimated Beam Diameter Prior to Lens: $\varnothing 3$ mm
- Wavelength: 633 nm

The specifications for the P1-630A-FC-2, 633 nm, FC/PC single mode patch cable indicate that the mode field diameter (MFD) is $4.3 \mu\text{m}$ at 633 nm. The MFD should be matched to the diffraction-limited spot size \varnothing_{spot} , which is given by the following equation:

$$\varnothing_{spot} = \frac{4\lambda f}{\pi D}$$

Here, f is the focal length of the lens, λ is the wavelength of the input light, and D

is the diameter of collimated beam incident on the lens. Solving for the desired focal length of the collimating lens yields:

$$f = \frac{\pi D(\text{MFD})}{4\lambda} = \frac{\pi(0.003 \text{ m})(4.3 \times 10^{-6} \text{ m})}{4(633 \times 10^{-9} \text{ m})} = 0.016 \text{ m} = 16 \text{ mm}$$

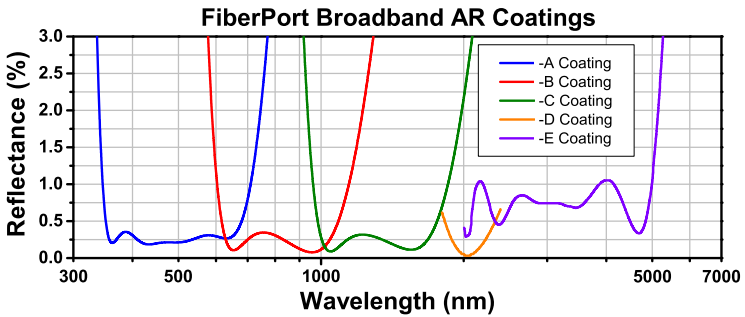
Thorlabs offers a large selection of FiberPorts. Scanning through the list of options under the *Specs* tab, you'll note that the FiberPort with a focal length closest to 16 mm has a focal length of 15.4 mm (Item # PAF-X-15-B), while also meeting the requirements for fiber connector and antireflection coating range. This FiberPort also has a clear aperture that is larger than the collimated beam diameter. Therefore, this is the best option given the initial parameters (i.e., a P1-630A-FC-2 single mode fiber and a collimated beam diameter of 3 mm).

Remember, for optimum coupling the spot size of the focused beam must be less than the MFD of the single mode fiber. As a result, if a FiberPort is not available that provides an exact match, then choose the FiberPort with a focal length that is shorter than the calculation above yields. Alternatively, if the clear aperture of the lens is large enough, the beam can be expanded before the lens, which has the result of reducing the spot size of the focused beam.

Please note that the NA listed in Chapters 2.1 and 2.2 is the NA of the lens, not the required numerical aperture of the fiber you are using. As long as the effective lens NA (calculated from the lens EFL and incoming beam diameter) is smaller than the NA of your fiber, you should be able to maximize the light coupled into your fiber. For best results, Thorlabs recommends using the equations above when choosing a FiberPort.

3.3. AR Coatings

Thorlabs offers FiberPort models with our A (350 - 700 nm, 400 - 600 nm, or 400 - 700 nm, depending upon the model), B (600 - 1050 nm), C (1050 - 1620 nm), D (1800 - 2400 nm), or E (2000 - 5000 nm) AR coatings. The plot below shows the typical per-surface reflectance of each AR coating. Each coating is available in FC/PC-, FC/APC-, and SMA-connectorized versions, except for the E coating, which is available in FC/PC- and SMA-connectorized versions. Care should be taken in selecting a FiberPort to make sure the correct fiber/connector/FiberPort combination is selected. If you need assistance, please contact tech support at your local office.



Chapter 4 Collimating Out of Fiber

1. Attach a connectorized single mode fiber source to the bulkhead of the FiberPort and examine the output.
2. Adjust the X-Y screws to center the output beam in the tilt plate aperture. It is important to maintain the X-Y screws in a position neither too tight or loose at all times or they may not function properly.
3. Trace the beam away from the FiberPort to check for collimation. (See Figure 5, shown below).
 - a. For a converging beam (beam comes to a focus): The lens is too far away from the fiber. Alternately turn the socket head cap screws (SHCS) clockwise in small, equal increments.
 - b. For a diverging beam (beam diameter continually increases): The lens is too close to the fiber. Alternately turn the SHCS counter clockwise in small, equal increments.
4. Check the beam path and adjust the X-Y screws as needed to re-center the beam in the output aperture.
5. Use progressively smaller adjustments until collimation is achieved and the desired beam centration is obtained.

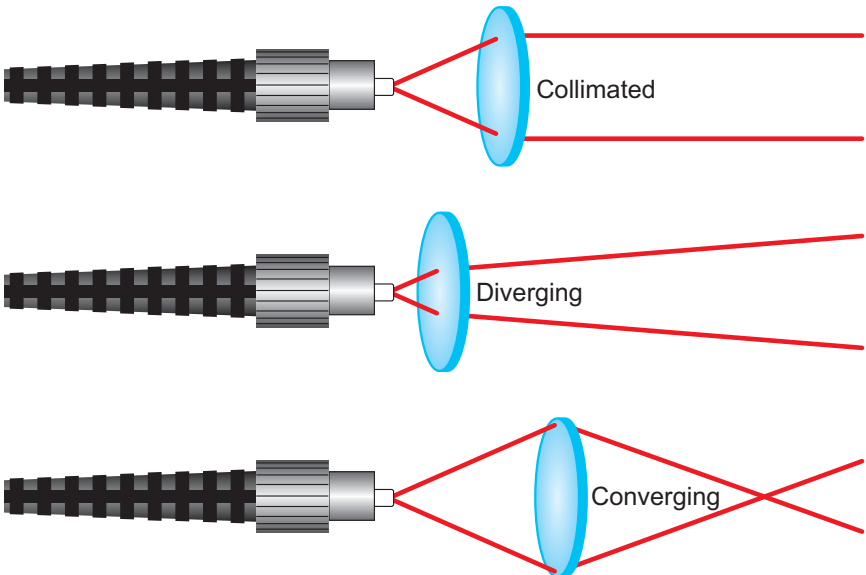


Figure 5 Three Lens Positions: Collimated, Converging, and Diverging Beams

Chapter 5 Coupling into a Fiber

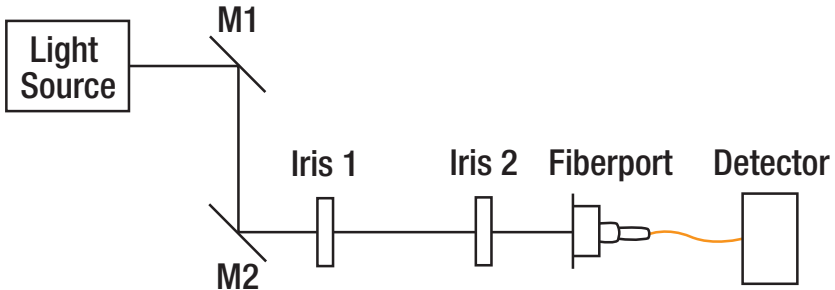


Figure 6 Setup for Coupling with the FiberPort

1. If possible, collimate light out of the FiberPort first (see Chapter 4). This will put the lens close to the correct position to start coupling. Also, the tilt plate should be level, so that the lens is free of tip or tilt. Please note that adjusting a FiberPort for coupling is an iterative process that takes time and practice.
2. In order to launch a free-space beam into the FiberPort effectively, it is essential that the incoming beam path be aligned with the central axis of the FiberPort. The diagram above illustrates a simple technique that can be implemented to achieve this alignment.
 - a. First, place two irises (set to the same height off the table) as shown in Figure 6 (above).
 - b. Adjust mirror 1 (M1) until the beam passes through the center of Iris 1, then adjust M2 to align the beam through the center of Iris 2. Iris 1 may need to be opened at this stage to allow the beam to pass through to Iris 2 during the initial part of alignment. Repeat this process iteratively until the beam is centered through both Iris 1 and Iris 2.
3. Place the FiberPort after Iris 2, as shown in Figure 6, shown above. Centering the input beam on the lens aperture of the FiberPort can be accomplished by affixing a target to the tilt plate in front of the lens.
 - a. Make adjustments to the FiberPort's position until the beam is visibly centered on the FiberPort aperture. The FiberPort can be mounted on to a HCP bracket mount, as shown in the image above, in order to adjust its position (see Chapter 8 for mounting accessories). Once the beam is centered, light should be clearly visible exiting the back of the FiberPort (with no fiber attached, as shown above). Make sure the beam is not visually clipped.

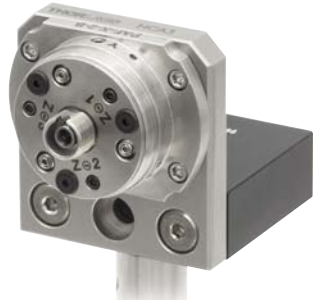


Figure 7 FiberPort Mounted on an HCP L-Bracket

4. Make sure the tip of the fiber is clean as this will maximize the amount of light coupled into the fiber. Once light is passing through the FiberPort, attach a multimode (MM) fiber (50 – 100 μm core) to the FiberPort, which will make the initial alignment process easier rather than coupling directly into a singlemode (SM) fiber.
5. Attach an optical detector to the end of the fiber not connected to the FiberPort and monitor the output signal. An optical detector has a faster response time than a power meter, and thus may be more helpful for fiberport alignment. Steps 2 and 3 should ensure that enough light is coupled into the fiber in order to detect an output signal at this stage. If you do not have any measurable power, repeat steps 2 and 3.
6. Use the X and Y adjustment screws to maximize the output signal. These adjustments are extremely sensitive. Small adjustments here translate to large coupling changes. The X and Y adjustments are coupled, so finding the maximum signal is an iterative process between the X and Y adjustments. Once the XY maximum is achieved, only VERY SMALL adjustments are needed. It is important to maintain the X-Y screws in a position neither too tight or loose at all times or they may not function properly.
7. Monitor and maximize the output signal while making small, **equal** adjustments in Z/q/j positioning socket head cap screws (SHCS). This will allow the lens to move in the Z direction without altering the tip/tilt. **Be sure to adjust the SHCS in equal increments.**

Note: In order to determine which way to adjust the screws, unscrew the fiber connector from the bulkhead and monitor the output as the fiber is retracted from the bulkhead. If the power increases, then the lens needs to move further away from the fiber, and if it decreases then the lens still has to move closer to the fiber. (Turn the SHCS clockwise to move the lens closer to the fiber, and counterclockwise to move the lens farther from the fiber.)

- a. Start at any SHCS on the face of the FiberPort and make very small adjustments to get a maximum in the output signal.
 - b. Move in a clockwise or counterclockwise direction to the next SHCS and make a similarly small adjustment.
 - c. Continue in the same direction with the final SHCS, and again make an equal adjustment.
 - d. After adjusting the SHCS, the signal may be lower than before the adjustment. Re-adjustment of the XY screws in the next step will show the increase in signal power.
8. Repeat step 6 (XY adjustment) to reach an absolute maximum signal. Note that adjusting the XY screws may involve losing the signal when the hex key is inserted into the setscrew, and then finding the signal again through slow adjustment. Adjust the X and Y screws iteratively to find an absolute maximum. Gains from Z-axis adjustment will now be evident.

If you intend to couple into an SM fiber, switch the MM fiber to an SM fiber at this point (once there is good coupling into the MM fiber after steps 5 and 6). It will be necessary to repeat steps 5 and 6 with the SM fiber in place to maximize the coupling.

Note: When coupling into SM fiber, even the smallest adjustments can drastically affect the coupling. When adjusting the SHCS be aware that by simply monitoring the power of the output signal, one can get stuck in a local maxima and never achieve best coupling. The ideal procedure is to make a small EQUAL adjustment in each of the SHCS in the chosen direction (see 6d above) and only monitor the power once all the screws have been adjusted. Usually, one will see a drop in power once the 2nd screw is adjusted but then a large increase in power when the 3rd screw is adjusted.

If you are using PM fiber, you can rotate the bulkhead to align the axis if needed. Please see Chapter 1 for more information on how to adjust the FiberPort bulkhead.

5.1. Coupling Light from a HeNe Laser

To couple light from a HeNe laser into a FiberPort using an HCL adapter, first attach the HCL to the HeNe laser using the 4-40 (M4) cap screws provided but do not fully tighten the screws. Next, attach the FiberPort to the HCL, and again, do not fully tighten the screws (See Figure 8 shown below). Maximum coupling can be achieved by adjusting these screws to center the beam into the FiberPort, while monitoring the output from the FiberPort (with no fiber attached). After the FiberPort is attached to the HeNe laser, the alignment procedure from Chapter 5 should be followed.



Figure 8 HCL Adapter Used to Connect the FiberPort to a HeNe Laser

When using the HNLS008 series of self-contained HeNe lasers, the HCL2 adapter should be used instead. This adapter attaches to the front of the HeNe using the 5/8"-32 threaded aperture. However, the HCL2 also features the slip-plate design of the HCL, and so the coupling procedure is similar. Simply thread the adapter onto the front of the HeNe, and then follow the procedures outlined above.

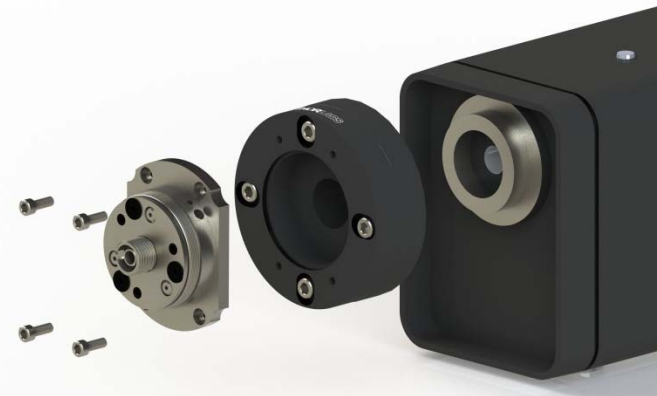


Figure 9 HCL2 Adapter Used to Connect the FiberPort to the HNLS008L Laser

Chapter 6 FiberPort to FiberPort on a Single-Axis FiberBench

Rough Alignment

1. Assemble the FiberBench with both ports on the FiberBench facing each other as shown to the right.
2. **Collimate beam from input FiberPort:** Attach an optical fiber to the input FiberPort in order to launch light into the FiberBench. Adjust the three SHCS screws in a near equal amount so the “Z” positioning is fine tuned to collimate the beam out of the fiber (see Chapter 4). It may only require very small adjustment.



Figure 10 Two FiberPorts Mounted on a Single-Axis FiberBench

3. **Center Beam on Output FiberPort:** Once good collimation is achieved, use slight (quarter or eighth) turns of the SHCS to steer the beam to the center of the other FiberPort. If this adjustment is not enough, DO NOT adjust the screws any more. Instead, set them back to the previous position which gave good collimation (from Step 2) and this time use the X-Y adjustment screws to move the lens in X-Y to steer the beam.
4. **Collimate and Center other FiberPort:** Repeat Steps 2 and 3 for the other FiberPort, launching light backward through the output fiber.
5. **Beam Waist at Center:** In order to maximize the coupling of light between the FiberPorts, place the waist of the beam at the center of the FiberBench between the two FiberPorts.

Fine Tuning

1. **Use Multimode Fiber for Coarse Alignment:** To align the FiberBench, start with multimode (50 – 100 μm core) fiber (if you have one) on the output port. The large core allows for easy coupling and good practice for the feel of the fiberport and which types of adjustments translate to coupling. This also helps to understand how quickly one can go out of alignment. NOTE: It does not help to use multimode fiber on the input port.
2. **Check Output Power:** Connect the output fiber to a suitable detector in order to determine and monitor the power coupled into the output fiber, and the quality of the alignment. Some power should be present from steps 2 – 4 at this stage (possibly only 10 – 250 nW). If there is no measurable power, repeat steps 2 – 4 again.

3. **Fine-tune Coupling:** Once you have a measurable signal from the output fiber, you can further improve and fine tune the alignment/coupling by making adjustments and monitoring the power level on the detector. See the section on fiber coupling for details.
4. **Switch to SM Fiber:** Once the alignment is optimized, you can switch to using SM fiber on the output FiberPort. You may need to repeat step 3 to optimize the coupling efficiency.

Chapter 7 Locking the FiberPort



CAUTION



Most applications DO NOT require locking.

If you are leaving the FiberPort on a table, it does not need to be locked. Typically, an aligned FiberPort can be hand carried and moved without causing alignment changes. The locking process can cause a shift in the alignment of the FiberPort. For situations where the FiberPort might undergo large vibrations or shock, such as shipping, we recommend locking or potting the FiberPort. Locking the FiberPort is an iterative process requiring patience. The locking screw pushes the lens cell firmly against the X and Y screws. If the locking screw is tightened too quickly, the alignment of the FiberPort LMC (Magnetic Lens Cell) will be shifted.

When locking the position of the LMC using the procedure below, monitor the position of the beam if the FiberPort is being used as a collimator. If the FiberPort is being used to couple light into a fiber, attach a suitable optical detector to the output end of the fiber and monitor the output signal of the detector during the locking process. In either case, make sure that the locking process does not change the alignment of the LMC.

1. Carefully thread the small locking screw into the FiberPort at the 7:30 o'clock position on the outer diameter.
2. As you slowly tighten the locking screw, adjust the X-Y screws as required to maintain the alignment. **DO NOT** torque down any of the screws. Applying too much pressure with the screws can permanently damage the magnet/lens assembly, the 0-80 screws, and/or destroy the alignment. When the X,Y, and locking screws are just snug, the lens is locking in place.
3. To prevent accidental changes in Z/q/j, carefully tighten the plunger screws with the small size hex wrench. Make minor adjustments to the SHCS as necessary to maintain the alignment of the LMC. **DO NOT** torque down any of the screws.
4. If optimal alignment is lost when locking, first loosen the locking screw two full turns, then loosen the plunger screws $\frac{1}{4}$ turn each. The less the plunger screws have to travel to be locked, the better. Now adjust the X-Y screws to regain optimal alignment. Repeat Steps 2 and 3.

Chapter 8 Other Accessories

HCL and HCL2 HeNe Laser Adapters

The HCL and HCL2 adapters allow a FiberPort to attach directly to the front of a HeNe laser utilizing a HeNe industry-standard four-bolt pattern, or the 5/8"-32 thread on Thorlabs' self-contained HeNe. This adapter includes the necessary 4-40 (M4) cap screws for attaching to a HeNe as well as four cap screws to attach a FiberPort. For added mounting options, the HCL features internal C-Mount threading, which is utilized on some lasers.



HCP L-Bracket Mount

The L-Bracket FiberPort mount has four 2-56 threaded holes for securing a FiberPort to the front plate. The bottom of the L-bracket can be easily attached to an optical table, a breadboard, or a post since it has 8-32 and M4 threaded holes as well as a counterbored through hole for a 1/4"-20 or an M6 screw.



CP08FP 30 mm Cage Mount

The CP08FP is designed to center a FiberPort inside a 30 mm cage system. The CP08FP secures to the four ER rods of a 30 mm cage assembly. Four #2-56 stainless steel socket head screws are included to secure a FiberPort to the adapter. The CP08FP has internal SM1 threading, enabling it to be used with our extensive line of lens tubes. This plate features a 8-32 tapped hole for post mounting, while the CP08FP/M has an M4 tapped hole for metric compatibility.



Multi-Axis FiberBench

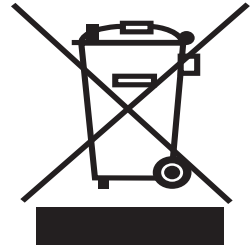
The FiberBench product selection offers platforms with support for three or more wall plates (HCA). Each table is designed so that multiple PAF series FiberPort fiber couplers/collimators can be used to assemble complex systems. An array of holes are positioned on the top surface to allow for the mounting of wave plates, polarizers, beamsplitters, and other optical components without the need for alignment and adjustment. The tables provide a common, compact, and stable platform for optical system designs with parallel and perpendicular beam propagation paths.



Chapter 9 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated



Wheelie Bin Logo

As the WEEE directive applies to self-contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e.g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

9.1. Waste Treatment is Your Own Responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

9.2. Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

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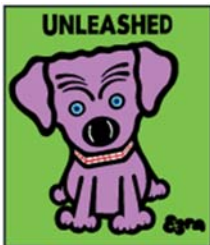
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THORLABS

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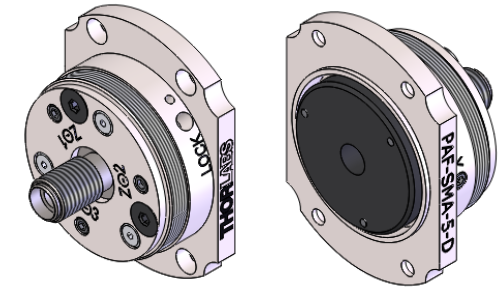
Allegato C15) Collimatori IR (fibra-porta filtri-sensore)

Attachment C15) IR Collimators (fiber-filters holder-detector)

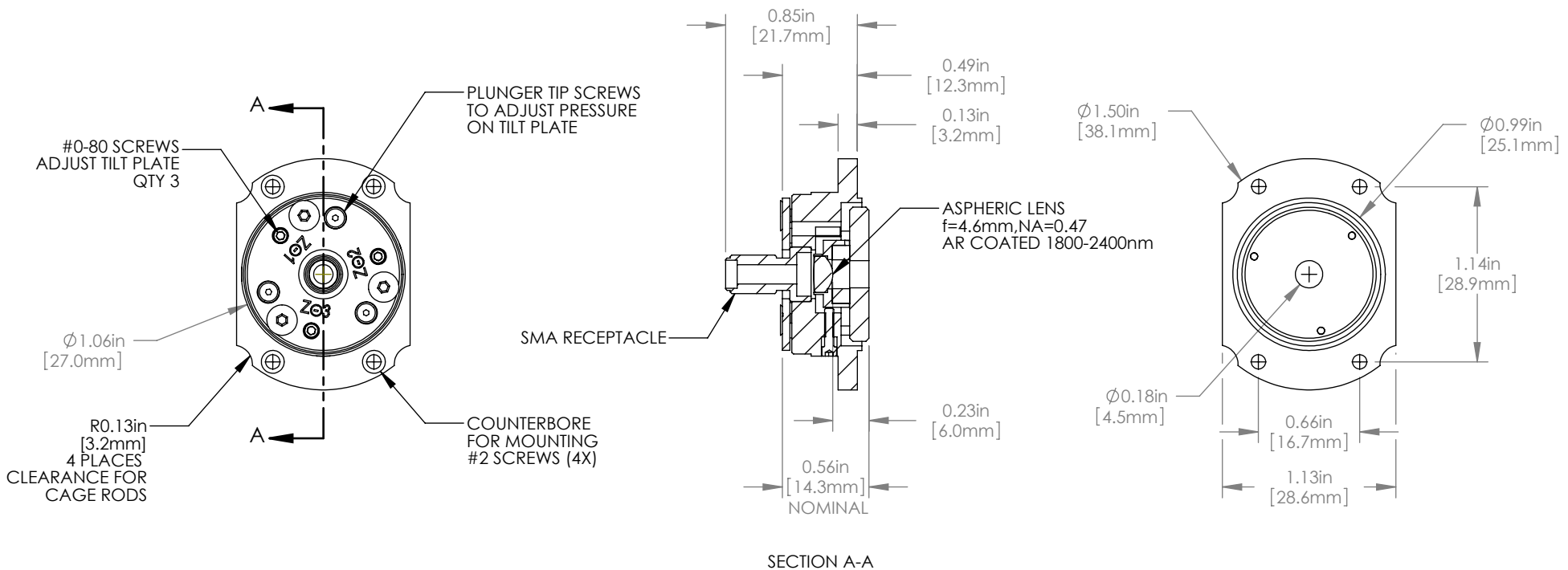
SPECIFICATIONS

INPUT MFD FROM SM2000 FIBER*	OUTPUT 1/e ² WAIST DIAMETER*	MAX WAIST DISTANCE*	DIVERGENCE*	LENS CLEAR APERTURE
13 μm	0.90 mm	164 mm	2.826 mrad	4.9 mm

*CALCULATED USING 2000nm WAVELENGTH



ISOMETRIC VIEW
SCALE 1:1



NOTES:
EACH FIBERPORT IS FACTORY ALIGNED FOR COLLIMATION AT 1550nm.

INCLUDED BUT NOT SHOWN:

- DUST CAP
- 0.035 HEX KEY
- 0.050 HEX KEY
- 0-80 LOCKING SCREW

FOR INFORMATION ONLY
NOT FOR MANUFACTURING PURPOSES

DRAWING PROJECTION				THORLABS www.thorlabs.com	
NAME	DATE	FIBERPORT, SMA, f=4.6 mm, 1800 - 2400 nm, $\phi 0.90$ mm WAIST			
DRAWN	PH	31/AUG/12	MATERIAL		REV B
APPROVAL	CB	23/OCT/14	N/A		
COPYRIGHT © 2014 BY THORLABS					
VALUES IN PARENTHESIS ARE CALCULATED AND MAY CONTAIN ROUND OFF ERRORS				ITEM #	APPROX WEIGHT
				PAF-SMA-5-D	0.09kg



**PAF Series
Aspheric and Achromatic
FiberPort Collimators with
FC/PC, FC/APC, or SMA
Adapters**

User Guide



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Chapter 1 Description

1.1. Mechanisms of the FiberPort

The FiberPort is a six-degree-of-freedom fiber collimator and coupler (5 axes, plus rotation). It uses a movable lens as the alignment mechanism while holding the fiber stationary. This provides an extremely stable and repeatable platform for coupling and collimating. All adjustments are coupled.

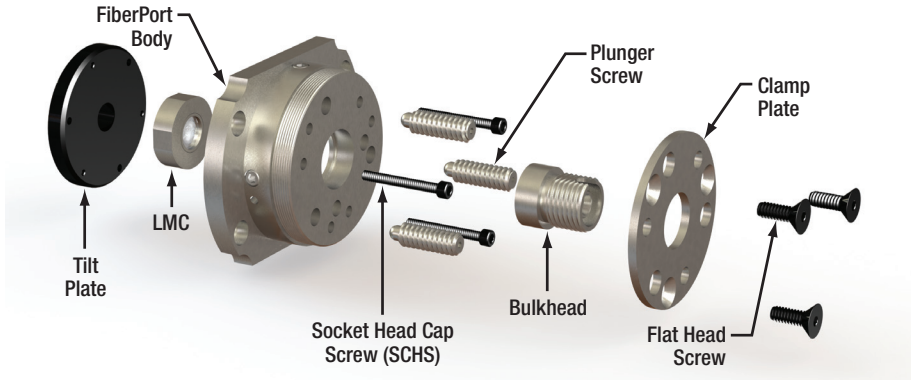


Figure 1 Components of a FiberPort

The FiberPort consists of a body, a Magnetic Lens Cell (LMC) adhered to a tilt plate, and a bulkhead with fiber connector. The bulkhead is locked onto the FiberPort body by three flat head screws and the clamp plate. By loosening the flat head screws, the fiber bulkhead can be rotated freely.

Z/q/j Adjustment

The LMC adheres to the tilt plate, which can be adjusted in Z/q/j (Axial, Tip, Tilt) using the three socket head cap screws (SCHS). The plunger screws provide counterforce against the SCHS. The Z (optical axis) translation range is ± 0.4 mm for a given position of the plunger screws. The plunger screws can translate the positive extreme of the travel range in the Z direction over a distance of 2 mm.

X-Y Adjustment

Additionally, the LMC can be translated in X-Y using the setscrews in the side of the fiberport body. The LMC rests on a leaf spring, and the X-Y screws push the cell against the leaf spring. A third setscrew behind the leaf spring can be used for locking. The travel range of the aspheric lens in the X and Y directions is ± 0.7 mm but when the FiberPort is used in a standard

collimation/coupling application only a small portion of this translation range is used.

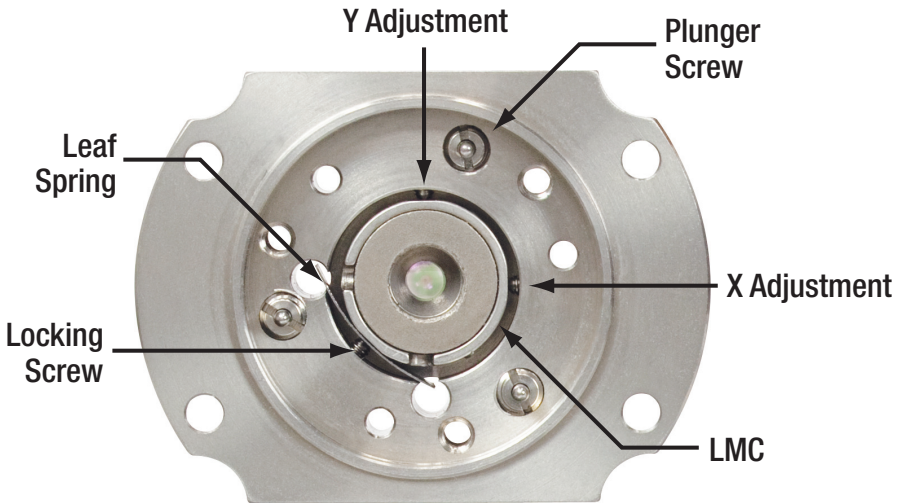


Figure 2 FiberPort Internal View: The Tilt Plate has Been Removed to Show the Lens Cell and Leaf Spring

The X-Y lens adjustment screws are located on the outer diameter of the FiberPort body at the 3 o'clock and the 12 o'clock positions. The three plunger screws provide counterforce for the tilt plate. The three socket head cap screws (SHCS) provide the Z/q/j adjustments for the FiberPort. The three SHCS and the X-Y screws are the only screws that are normally used in the alignment of the FiberPort. However, the plunger screws can be used to adjust the tension on the tilt plate if needed. Also, the three flat head screws on the face of the FiberPort hold the clamp plate and bulkhead in place. By loosening these screws, the bulkhead can be rotated a full 360° and secured at any angle for PM applications. This is a coarse adjustment, however.

The locking screw is located on the outer diameter of the FiberPort body at the 7:30 position. The locking screw is not installed when the FiberPort is shipped but is included in the package. The locking screw is only used after the FiberPort is aligned.

NOTE: Locking the FiberPort is not necessary in most applications and can affect coupling.

1.2. Location of Screws on the FiberPort

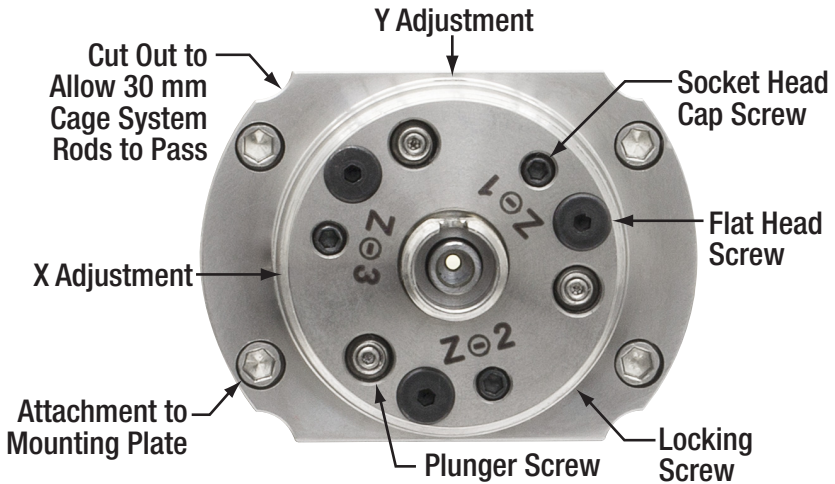


Figure 3 Location of Screws on the FiberPort

Part	Screw Size to Use	Head Size (Hex)
Mounting Plate Attachment Screws	2-56	5/64"
X, Y, and Locking Set Screws	0-80	0.050"
Z (Tip & Tilt) Socket Head Cap Screws	0-80	0.050"
Flat Head Screws	2-56	0.050"
Plunger Screws	6-32	0.035"

Chapter 2 Specifications

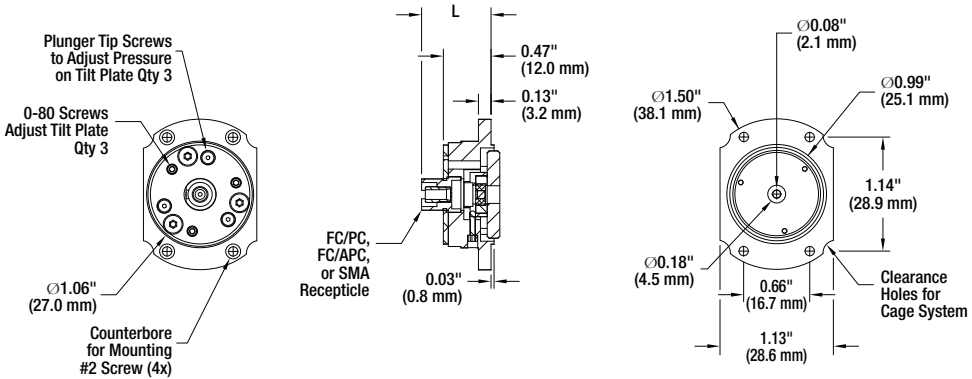


Figure 4 Schematic Diagram of the FiberPort

2.1. Achromatic FiberPorts

We offer achromatic FiberPorts as an alternative to our standard aspheric models. They perform similarly to our short focal length aspheric FiberPorts, but with a very small focal length shift over a broad wavelength range.

Item#	EFL (mm)	Input MFD ¹ (µm)	Output Waist Dia. (1/e ²) (mm)	Max Waist Dist. ² (mm)	Diverg. (mrad)	Focal Length Shift ³ (µm)	Lens Characteristics			Length L (in/mm)
							CA ⁴ (mm)	NA	AR Range ⁵ (nm)	
PAFA-X-4-A	4.0	3.5	0.65	378	0.875	8.3	1.8	0.22	400 - 700	0.69/17.5
PAFA-X-4-B	4.0	5.0	0.87	350	1.250	6.9	1.8	0.22	600 - 1050	0.69/17.5
PAFA-X-4-C	4.0	10.4	0.76	150	2.600	14.8	1.8	0.22	1050 - 1620	0.69/17.5

1) Mode-Field Diameter. This spec was calculated using the following equipment:

PAFA-X-4-A: 460HP at 450 nm

PAFA-X-4-B: 780HP at 850 nm

PAFA-X-4-C: SMF-28e+ at 1550 nm

2) Maximum Waist Distance: The max distance from the lens a Gaussian beam's waist can be placed.

3) Focal length shift is defined over the entire AR coating range.

4) Clear Aperture

5) Wavelength of the Antireflection Coating

2.2. Aspheric FiberPorts

Our standard aspheric lens FiberPorts are available with a variety of focal length and coating options. The first table details all of our SMA-compatible FiberPorts. PAF-X-2, -4, -5, and -7 FiberPorts in the second table have a straight FC bulkhead which will work with FC/PC and FC/APC connectors. The PAF-X-11, -15, and -18 in the last table come with either FC/PC- or FC/APC-compatible bulkheads.

All Focal Lengths, SMA-Compatible

Item#	EFL (mm)	Input MFD ¹ (μm)	Output Waist Dia. ($1/e^2$) (mm)	Max Waist Dist. ² (mm)	Diverg. (mrad)	Lens Characteristics			Length L (in/mm)
						CA ³ (mm)	NA	AR Range (nm) ⁴	
PAF-SMA-4-E	4.0	14.47	1.23	169	3.617	5.0	0.56	2000 - 5000	0.85/21.7
PAF-SMA-5-A	4.6	3.5	0.75	499	0.761	4.9	0.47	350 - 700	0.85/21.7
PAF-SMA-5-B	4.6	5.0	1.00	463	1.087	4.9	0.47	600 - 1050	0.85/21.7
PAF-SMA-5-C	4.6	10.4	0.87	198	2.261	4.9	0.47	1050 - 1620	0.85/21.7
PAF-SMA-5-D	4.6	13	0.90	164	2.826	4.9	0.47	1800 - 2400	0.85/21.7
PAF-SMA-7-A	7.5	3.5	1.23	1323	0.467	4.4	0.29	350 - 700	0.85/21.7
PAF-SMA-7-B	7.5	5.0	1.62	1125	0.667	4.4	0.29	600 - 1050	0.85/21.7
PAF-SMA-7-C	7.5	10.4	1.42	521	1.387	4.4	0.29	1050 - 1620	0.85/21.7
PAF-SMA-11-A	11.0	3.5	1.80	2841	0.318	4.4	0.20	350 - 700	1.04/26.3
PAF-SMA-11-B	11.0	5.0	2.38	2630	0.455	4.4	0.20	600 - 1050	1.04/26.3
PAF-SMA-11-C	11.0	10.4	2.09	1115	0.945	4.4	0.20	1050 - 1620	1.04/26.3
PAF-SMA-11-D	11.0	13	2.15	923	1.182	4.4	0.20	1800 - 2400	1.04/26.3
PAF-SMA-11-E	11.0	14.47	3.39	1258	1.315	4.0	0.18	2000 - 5000	1.04/26.3

- 1) Mode Field Diameter. Calculated using the following equipment: -A: 460HP at 450 nm, -B: 780HP at 850 nm, -C: SMF-28e+ at 1550 nm, -D: SM2000 at 2000 nm, -E: ZrF₄ at 3.39 μm
- 2) Maximum Waist Distance: The max distance from the lens a Gaussian beam's waist can be placed.
- 3) Clear Aperture
- 4) Wavelength Range of the Antireflection Coating

Short Focal Length, FC/PC and FC/APC Compatible

Item#	EFL (mm)	Input MFD ¹ (μm)	Output Waist Dia. ($1/e^2$) (mm)	Max Waist Dist. ² (mm)	Diverg. (mrad)	Lens Characteristics			Length L (in/mm)
						CA ³ (mm)	NA	AR Range ⁴ (nm)	
PAF-X-2-A	2.0	3.5	0.33	96	1.750	2.0	0.45	350 - 700	0.65/16.6
PAF-X-2-B	2.0	5.0	0.43	89	2.500	2.0	0.45	600 - 1050	0.65/16.6
PAF-X-2-C	2.0	10.4	0.38	38	5.200	2.0	0.45	1050 - 1620	0.65/16.6
PAF-X-4-E	4.0	14.47	1.23	169	3.617	5.0	0.56	2000 - 5000	0.69/17.5
PAF-X-5-A	4.6	3.5	0.75	499	0.761	4.9	0.47	350 - 700	0.69/17.5
PAF-X-5-B	4.6	5.0	1.00	463	1.087	4.9	0.47	600 - 1050	0.69/17.5
PAF-X-5-C	4.6	10.4	0.87	198	2.261	4.9	0.47	1050 - 1600	0.69/17.5
PAF-X-5-D	4.6	13	0.90	164	2.826	4.9	0.47	1800 - 2400	0.69/17.5
PAF-X-7-A	7.5	3.5	1.23	1323	0.467	4.4	0.29	350 - 700	0.69/17.5
PAF-X-7-B	7.5	5.0	1.62	1225	0.667	4.4	0.29	600 - 1050	0.69/17.5
PAF-X-7-C	7.5	10.4	1.42	521	1.387	4.4	0.29	1050 - 1620	0.69/17.5

- 1) Mode Field Diameter. Calculated using the following equipment: -A: 460HP at 450 nm, -B: 780HP at 850 nm, -C: SMF-28e+ at 1550 nm, -D: SM2000 at 2000 nm, -E: ZrF₄ at 3.39 μm
- 2) Maximum Waist Distance: The max distance from the lens a Gaussian beam's waist can be placed.
- 3) Clear Aperture
- 4) Wavelength Range of the Antireflection Coating

Long Focal Length, FC/APC or FC/PC Compatible

Item#	EFL (mm)	Input MFD ¹ (μm)	Output Waist Dia. ($1/e^2$) (mm)	Max Waist Dist. ² (mm)	Diverg. (mrad)	Lens Characteristics			Length L (in/mm)
						CA ³ (mm)	NA	AR Range (nm) ⁴	
FC/APC Compatible									
PAF-X-11-A	11.0	3.5	1.80	2841	0.318	4.4	0.20	350 - 700	0.87/22.0
PAF-X-11-B	11.0	5.0	2.38	2630	0.455	4.4	0.20	600 - 1050	0.87/22.0
PAF-X-11-C	11.0	10.4	2.09	1115	0.945	4.4	0.20	1050 - 1620	0.87/22.0
PAF-X-11-D	11.0	13	2.15	923	1.182	4.4	0.20	1800 - 2400	0.87/22.0
PAF-X-15-A	15.4	3.5	2.52	5562	0.227	5.0	0.16	350 - 700	0.87/22.0
PAF-X-15-B	15.4	5.0	3.33	5149	0.325	5.0	0.16	600 - 1050	0.87/22.0
PAF-X-15-C	15.4	10.4	2.92	2179	0.675	5.0	0.16	1050 - 1620	0.87/22.0
PAF-X-15-D	15.4	13	3.02	1802	0.844	5.0	0.16	1800 - 2400	0.87/22.0
PAF-X-18-A	18.4	3.5	3.01	7936	0.190	5.5	0.15	350 - 700	0.87/22.0
PAF-X-18-B	18.4	5.0	3.98	7347	0.272	5.5	0.15	600 - 1050	0.87/22.0
PAF-X-18-C	18.4	10.4	3.49	3107	0.565	5.5	0.15	1050 - 1620	0.87/22.0
PAF-X-18-D	18.4	13	3.60	2569	0.707	5.5	0.15	1800 - 2400	0.87/22.0
FC/PC Compatible									
PAF-X-11-PC-A	11.0	3.5	1.80	2841	0.318	4.4	0.20	350 - 700	0.87/22.0
PAF-X-11-PC-B	11.0	5.0	2.38	2630	0.455	4.4	0.20	600 - 1050	0.87/22.0
PAF-X-11-PC-C	11.0	10.4	2.09	1115	0.945	4.4	0.20	1050 - 1620	0.87/22.0
PAF-X-11-PC-D	11.0	13	2.15	923	1.182	4.4	0.20	1800 - 2400	0.87/22.0
PAF-X-11-PC-E	11.0	14.47	3.39	1258	1.315	4.0	0.18	2000 - 5000	0.87/22.0
PAF-X-15-PC-A	15.4	3.5	2.52	5562	0.227	5.0	0.16	350 - 700	0.87/22.0
PAF-X-15-PC-B	15.4	5.0	3.33	5149	0.325	5.0	0.16	600 - 1050	0.87/22.0
PAF-X-15-PC-C	15.4	10.4	2.92	2179	0.675	5.0	0.16	1050 - 1620	0.87/22.0
PAF-X-15-PC-D	15.4	13	3.02	1802	0.844	5.0	0.16	1800 - 2400	0.87/22.0
PAF-X-18-PC-A	18.4	3.5	3.01	8936	0.190	5.5	0.15	350 - 700	0.69/17.5
PAF-X-18-PC-B	18.4	5.0	3.98	7347	0.272	5.5	0.15	600 - 1050	0.69/17.5
PAF-X-18-PC-C	18.4	10.4	3.49	3107	0.565	5.5	0.15	1050 - 1620	0.69/17.5
PAF-X-18-PC-D	18.4	13	3.60	2569	0.707	5.5	0.15	1800 - 2400	0.69/17.5

- 1) Mode Field Diameter. Calculated using the following equipment: -A: 460HP at 450 nm, -B: 780HP at 850 nm, -C: SMF-28e+ at 1550 nm, -D: SM2000 at 2000 nm, -E: ZrF₄ at 3.39 μm
- 2) Maximum Waist Distance: The max distance from the lens a Gaussian beam's waist can be placed
- 3) Clear Aperture
- 4) Wavelength Range of the Antireflection Coating

2.3. Lens Materials

Item #	Material
PAF-xxx-2-x	ECO-550
PAFA-X-4-A*	N-SK16/N-LASF9
PAFA-X-4-B*	N-LAK22/N-SF6HT
PAFA-X-4-C*	N-SF66/N-LASF41
PAF-xxx-4-E	Black Diamond-2
PAF-xxx-5-x	H-LAK54
PAF-xxx-7-x	H-LAK54
PAF-xxx-11-A	H-LAK54
PAF-xxx-11-B	H-LAK54
PAF-xxx-11-C	H-LAK54
PAF-xxx-11-D	H-LAK54
PAF-xxx-11-E	Black Diamond-2
PAF-xxx-15-x	ECO-550
PAF-xxx-18-x	ECO-550

**Achromatic doublet lenses. All other FiberPorts use aspheric lenses.*

Chapter 3 FiberPort Guide

3.1. Selection Table

The table below can be used as a selection guide to determine which FiberPort would best suit your needs.

Item#	EFL (mm)	Coupling Input Beam Diameter (mm)	Collimated Output Beam Diameter (mm)	Best Collimation Distance at	Connector Compatibility
PAF-X-2-λ	2.0	0.3 – 0.8	0.33	1 – 20 cm	All FC
PAF-X-5-λ	4.6	0.8 – 1.4	0.75	10 cm & Beyond	All FC
PAF-X-7-λ	7.5	1.2 – 2.0	1.4	20 cm & Beyond	All FC
PAF-X-11-λ	11.0	1.9 – 3.0	2.1	20 cm & Beyond	FC/APC
PAF-X-11-λ-PC	11.0	1.9 – 3.0	2.1	20 cm & Beyond	FC/PC
PAF-X-15-λ	15.4	2.8 – 4.0	2.9	30 cm & Beyond	FC/APC
PAF-X-15-λ-PC	15.4	2.8 – 4.0	2.9	30 cm & Beyond	FC/PC
PAF-X-18-λ	18.0	3.4 – 4.7	3.5	30 cm & Beyond	FC/APC
PAF-X-18-λ-PC	18.0	3.4 – 4.7	3.5	30 cm & Beyond	FC/PC

Note: PAF-X-2, -5, and -7 FiberPorts have a straight FC bulkhead which will work with FC/PC and FC/APC connectors. The PAF-X-11, -15, and -18 come with either PC or APC compatible bulkheads. Please specify which type of connector you will be using when ordering a PAF-X-11 through -18 FiberPort.

3.2. Selection Example

The example presented here details the steps needed to ensure proper selection of a FiberPort to match the requirements of a particular fiber. For specific recommendations, please contact TechSupport@thorlabs.com.

- Fiber: P1-630A-FC-2
- Collimated Beam Diameter Prior to Lens: Ø3 mm
- Wavelength: 633 nm

The specifications for the P1-630A-FC-2, 633 nm, FC/PC single mode patch cable indicate that the mode field diameter (MFD) is 4.3 μm at 633 nm. The MFD should be matched to the diffraction-limited spot size ϕ_{spot} , which is given by the following equation:

$$\phi_{spot} = \frac{4\lambda f}{\pi D}$$

Here, f is the focal length of the lens, λ is the wavelength of the input light,

and D is the diameter of collimated beam incident on the lens. Solving for the desired focal length of the collimating lens yields:

$$f = \frac{\pi D(\text{MFD})}{4\lambda} = \frac{\pi(0.003 \text{ m})(4.3 \times 10^{-6} \text{ m})}{4(633 \times 10^{-9} \text{ m})} = 0.016 \text{ m} = 16 \text{ mm}$$

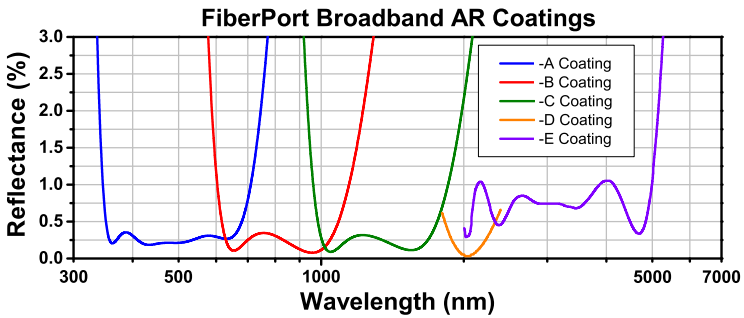
Thorlabs offers a large selection of FiberPorts. Scanning through the list of options under the *Specs* tab, you'll note that the FiberPort with a focal length closest to 16 mm has a focal length of 15.4 mm (Item # PAF-X-15-B), while also meeting the requirements for fiber connector and antireflection coating range. This FiberPort also has a clear aperture that is larger than the collimated beam diameter. Therefore, this is the best option given the initial parameters (i.e., a P1-630A-FC-2 single mode fiber and a collimated beam diameter of 3 mm).

Remember, for optimum coupling the spot size of the focused beam must be less than the MFD of the single mode fiber. As a result, if a FiberPort is not available that provides an exact match, then choose the FiberPort with a focal length that is shorter than the calculation above yields. Alternatively, if the clear aperture of the lens is large enough, the beam can be expanded before the lens, which has the result of reducing the spot size of the focused beam.

Please note that the NA listed in Chapters 2.1 and 2.2 is the NA of the lens, not the required numerical aperture of the fiber you are using. As long as the lens NA is at least as large as the NA of your fiber, you should be able to couple light. For best results, Thorlabs recommends using the equations above when choosing a FiberPort.

3.3. AR Coatings

Thorlabs offers FiberPort models with our A (350 - 700 nm, 400 - 600 nm, or 400 - 700 nm, depending upon the model), B (600 - 1050 nm), C (1050 - 1620 nm), D (1800 - 2400 nm), or E (2000 - 5000 nm) AR coatings. The plot below shows the typical per-surface reflectance of each AR coating. Each coating is available in FC/PC-, FC/APC-, and SMA-connectorized versions, except for the E coating, which is available in FC/PC- and SMA-connectorized versions. Care should be taken in selecting a FiberPort to make sure the correct fiber/connector/FiberPort combination is selected. If you need assistance, please contact tech support at your local office.



Chapter 4 Collimating Out of Fiber

1. Attach a connectorized single mode fiber source to the bulkhead of the FiberPort and examine the output.
2. Adjust the X-Y screws to center the output beam in the tilt plate aperture. It is important to maintain the X-Y screws in a position neither too tight or loose at all times or they may not function properly.
3. Trace the beam away from the FiberPort to check for collimation. (See Figure 5, shown below).
 - a. For a converging beam (beam comes to a focus): The lens is too far away from the fiber. Alternately turn the socket head cap screws (SHCS) clockwise in small, equal increments.
 - b. For a diverging beam (beam diameter continually increases): The lens is too close to the fiber. Alternately turn the SHCS counter clockwise in small, equal increments.
4. Check the beam path and adjust the X-Y screws as needed to re-center the beam in the output aperture.
5. Use progressively smaller adjustments until collimation is achieved and the desired beam centration is obtained.

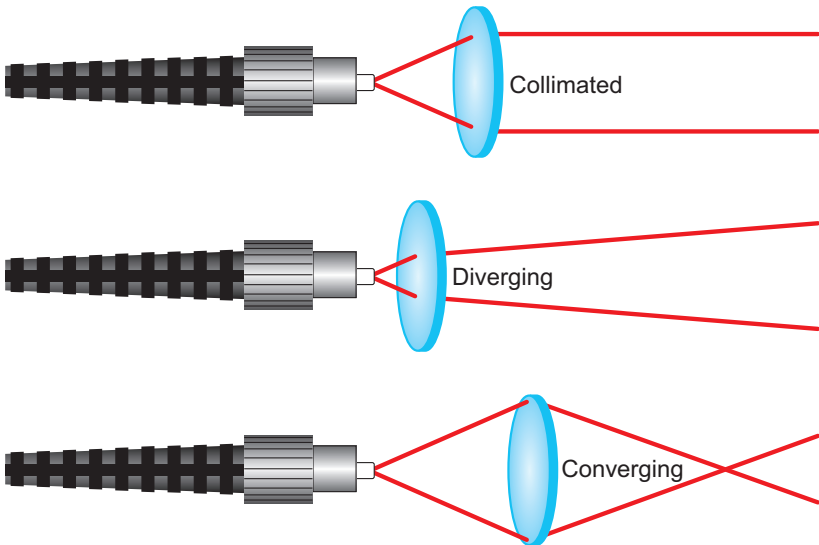


Figure 5 Three Lens Positions: Collimated, Converging, and Diverging Beams

Chapter 5 Coupling into a Fiber

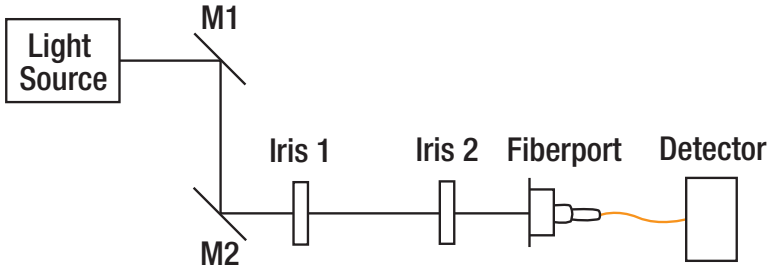


Figure 6 Setup for Coupling with the FiberPort

1. If possible, collimate light out of the FiberPort first (see Chapter 4). This will put the lens close to the correct position to start coupling. Also, the tilt plate should be level, so that the lens is free of tip or tilt. Please note that adjusting a FiberPort for coupling is an iterative process that takes time and practice.
2. In order to launch a free-space beam into the FiberPort effectively, it is essential that the incoming beam path be aligned with the central axis of the FiberPort. The diagram above illustrates a simple technique that can be implemented to achieve this alignment.
 - a. First, place two irises (set to the same height off the table) as shown in Figure 6 (above).
 - b. Adjust mirror 1 (M1) until the beam passes through the center of Iris 1, then adjust M2 to align the beam through the center of Iris 2. Iris 1 may need to be opened at this stage to allow the beam to pass through to Iris 2 during the initial part of alignment. Repeat this process iteratively until the beam is centered through both Iris 1 and Iris 2.
3. Place the FiberPort after Iris 2, as shown in Figure 6, shown above. Centering the input beam on the lens aperture of the FiberPort can be accomplished by affixing a target to the tilt plate in front of the lens.
 - a. Make adjustments to the FiberPort's position until the beam is visibly centered on the FiberPort aperture. The FiberPort can be mounted on to a HCP bracket mount, as shown in the image above, in order to adjust its position (see Chapter 8 for mounting accessories). Once the beam is centered, light should be clearly visible exiting the back of the FiberPort (with no fiber

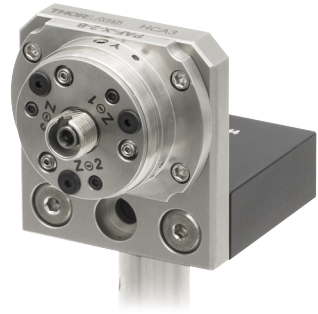


Figure 7 FiberPort Mounted on an HCP L-Bracket

attached, as shown above). Make sure the beam is not visually clipped.

4. Make sure the tip of the fiber is clean as this will maximize the amount of light coupled into the fiber. Once light is passing through the FiberPort, attach a multimode (MM) fiber (50 – 100 μm core) to the FiberPort, which will make the initial alignment process easier rather than coupling directly into a singlemode (SM) fiber.
5. Attach an optical detector to the end of the fiber not connected to the FiberPort and monitor the output signal. An optical detector has a faster response time than a power meter, and thus may be more helpful for fiberport alignment. Steps 2 and 3 should ensure that enough light is coupled into the fiber in order to detect an output signal at this stage. If you do not have any measurable power, repeat steps 2 and 3.
6. Use the X and Y adjustment screws to maximize the output signal. These adjustments are extremely sensitive. Small adjustments here translate to large coupling changes. The X and Y adjustments are coupled, so finding the maximum signal is an iterative process between the X and Y adjustments. Once the XY maximum is achieved, only VERY SMALL adjustments are needed. It is important to maintain the X-Y screws in a position neither too tight or loose at all times or they may not function properly.
7. Monitor and maximize the output signal while making small, **equal** adjustments in Z/q/j positioning socket head cap screws (SHCS). This will allow the lens to move in the Z direction without altering the tip/tilt. **Be sure to adjust the SHCS in equal increments.**

Note: In order to determine which way to adjust the screws, unscrew the fiber connector from the bulkhead and monitor the output as the fiber is retracted from the bulkhead. If the power increases, then the lens needs to move further away from the fiber, and if it decreases then the lens still has to move closer to the fiber. (Turn the SCHS clockwise to move the lens closer to the fiber, and counterclockwise to move the lens farther from the fiber.)

- a. Start at any SHCS on the face of the FiberPort and make very small adjustments to get a maximum in the output signal.
- b. Move in a clockwise or counterclockwise direction to the next SHCS and make a similarly small adjustment.
- c. Continue in the same direction with the final SHCS, and again make an equal adjustment.
- d. After adjusting the SHCS, the signal may be lower than before the adjustment. Re-adjustment of the XY screws in the next step will show the increase in signal power.

8. Repeat step 6 (XY adjustment) to reach an absolute maximum signal. Note that adjusting the XY screws may involve losing the signal when the hex key is inserted into the setscrew, and then finding the signal again through slow adjustment. Adjust the X and Y screws iteratively to find an absolute maximum. Gains from Z-axis adjustment will now be evident.

If you intend to couple into an SM fiber, switch the MM fiber to an SM fiber at this point (once there is good coupling into the MM fiber after steps 5 and 6). It will be necessary to repeat steps 5 and 6 with the SM fiber in place to maximize the coupling.

Note: When coupling into SM fiber, even the smallest adjustments can drastically affect the coupling. When adjusting the SHCS be aware that by simply monitoring the power of the output signal, one can get stuck in a local maxima and never achieve best coupling. The ideal procedure is to make a small EQUAL adjustment in each of the SHCS in the chosen direction (see 6d above) and only monitor the power once all the screws have been adjusted. Usually, one will see a drop in power once the 2nd screw is adjusted but then a large increase in power when the 3rd screw is adjusted.

If you are using PM fiber, you can rotate the bulkhead to align the axis if needed. Please see Chapter 1 for more information on how to adjust the FiberPort bulkhead.

5.1. Coupling Light from a HeNe Laser

To couple light from a HeNe laser into a FiberPort using an HCL adapter, first attach the HCL to the HeNe laser using the 4-40 (M4) cap screws provided but do not fully tighten the screws. Next, attach the FiberPort to the HCL, and again, do not fully tighten the screws (See Figure 8 shown below). Maximum coupling can be achieved by adjusting these screws to center the beam into the FiberPort, while monitoring the output from the FiberPort (with no fiber attached). After the FiberPort is attached to the HeNe laser, the alignment procedure from Chapter 5 should be followed.

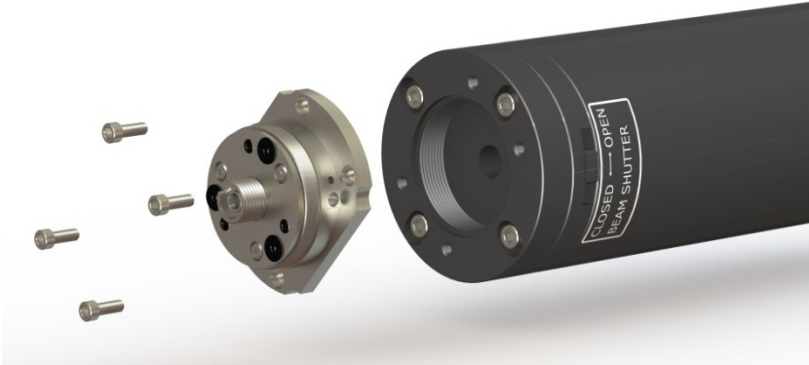


Figure 8 HCL Adapter Used to Connect the FiberPort to a HeNe Laser

When using the HNLS008 series of self-contained HeNe lasers, the HCL2 adapter should be used instead. This adapter attaches to the front of the HeNe using the 5/8"-32 threaded aperture. However, the HCL2 also features the slip-plate design of the HCL, and so the coupling procedure is similar. Simply thread the adapter onto the front of the HeNe, and then follow the procedures outlined above.

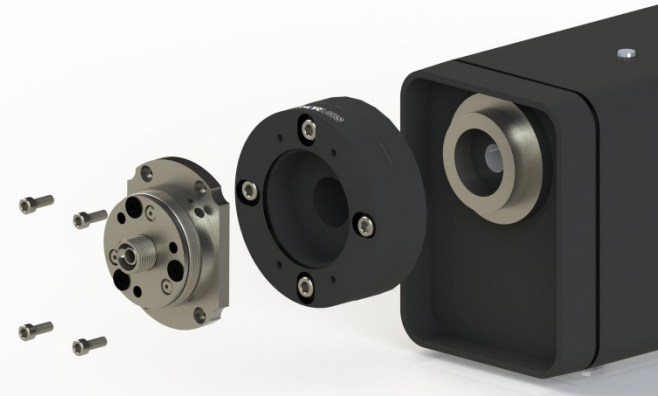


Figure 9 HCL2 Adapter Used to Connect the Fiberport to the HNLS008L Laser

Chapter 6 FiberPort to FiberPort on a Single-Axis FiberBench

Rough Alignment

1. Assemble the FiberBench with both ports on the FiberBench facing each other as shown to the right.
2. **Collimate beam from input FiberPort:** Attach an optical fiber to the input FiberPort in order to launch light into the FiberBench. Adjust the three SHCS screws in a near equal amount so the “Z” positioning is fine tuned to collimate the beam out of the fiber (see Chapter 4). It may only require very small adjustment.



Figure 10 Two FiberPorts Mounted on a Single-Axis FiberBench

3. **Center Beam on Output FiberPort:** Once good collimation is achieved, use slight (quarter or eighth) turns of the SHCS to steer the beam to the center of the other FiberPort. If this adjustment is not enough, DO NOT adjust the screws any more. Instead, set them back to the previous position which gave good collimation (from Step 2) and this time use the X-Y adjustment screws to move the lens in X-Y to steer the beam.
4. **Collimate and Center other FiberPort:** Repeat Steps 2 and 3 for the other FiberPort, launching light backward through the output fiber.
5. **Beam Waist at Center:** In order to maximize the coupling of light between the FiberPorts, place the waist of the beam at the center of the FiberBench between the two FiberPorts.

Fine Tuning

1. **Use Multimode Fiber for Coarse Alignment:** To align the FiberBench, start with multimode (50 – 100 μm core) fiber (if you have one) on the output port. The large core allows for easy coupling and good practice for the feel of the fiberport and which types of adjustments translate to coupling. This also helps to understand how quickly one can go out of alignment. NOTE: It does not help to use multimode fiber on the input port.
2. **Check Output Power:** Connect the output fiber to a suitable detector in order to determine and monitor the power coupled into the output fiber, and the quality of the alignment. Some power should be

present from steps 2 – 4 at this stage (possibly only 10 – 250 nW). If there is no measurable power, repeat steps 2 – 4 again.

3. **Fine-tune Coupling:** Once you have a measurable signal from the output fiber, you can further improve and fine tune the alignment/coupling by making adjustments and monitoring the power level on the detector. See the section on fiber coupling for details.

4. **Switch to SM Fiber:** Once the alignment is optimized, you can switch to using SM fiber on the output FiberPort. You may need to repeat step 3 to optimize the coupling efficiency.

Chapter 7 Locking the FiberPort



CAUTION



Most applications DO NOT require locking.

If you are leaving the FiberPort on a table, it does not need to be locked. Screw on the black end cap to minimize unauthorized alignment changes. Typically, an aligned FiberPort can be hand carried and moved without causing alignment changes. The locking process can cause a shift in the alignment of the FiberPort. For situations where the FiberPort might undergo large vibrations or shock, such as shipping, we recommend locking or potting the FiberPort. Locking the FiberPort is an iterative process requiring patience. The locking screw pushes the lens cell firmly against the X and Y screws. If the locking screw is tightened too quickly, the alignment of the FiberPort LMC (Magnetic Lens Cell) will be shifted.

When locking the position of the LMC using the procedure below, monitor the position of the beam if the FiberPort is being used as a collimator. If the FiberPort is being used to couple light into a fiber, attach a suitable optical detector to the output end of the fiber and monitor the output signal of the detector during the locking process. In either case, make sure that the locking process does not change the alignment of the LMC.

1. Carefully thread the small locking screw into the FiberPort at the 7:30 o'clock position on the outer diameter.
2. As you slowly tighten the locking screw, adjust the X-Y screws as required to maintain the alignment. DO NOT torque down any of the screws. Applying too much pressure with the screws can permanently damage the magnet/lens assembly, the 0-80 screws, and/or destroy the alignment. When the X,Y, and locking screws are just snug, the lens is locking in place.
3. To prevent accidental changes in Z/q/j, carefully tighten the plunger screws with the small size hex wrench. Make minor adjustments to the SHCS as necessary to maintain the alignment of the LMC. DO NOT torque down any of the screws.
4. If optimal alignment is lost when locking, first loosen the locking screw two full turns, then loosen the plunger screws ¼ turn each. The less the plunger screws have to travel to be locked, the better. Now adjust the X-Y screws to regain optimal alignment. Repeat Steps 2 and 3.
5. Screw the black end cap on to discourage any further adjustment of the alignment screws.

Chapter 8 Other Accessories

HCL and HCL2 HeNe Laser Adapters

The HCL and HCL2 adapters allow a FiberPort to attach directly to the front of a HeNe laser utilizing a HeNe industry-standard four-bolt pattern, or the 5/8"-32 thread on Thorlabs' self-contained HeNe. This adapter includes the necessary 4-40 (M4) cap screws for attaching to a HeNe as well as four cap screws to attach a FiberPort. For added mounting options, the HCL features internal C-Mount threading, which is utilized on some lasers.



HCP L-Bracket Mount

The L-Bracket FiberPort mount has four 2-56 threaded holes for securing a FiberPort to the front plate. The bottom of the L-bracket can be easily attached to an optical table, a breadboard, or a post since it has 8-32 and M4 threaded holes as well as a counterbored through hole for a 1/4"-20 or an M6 screw.



CP08FP 30 mm Cage Mount

The CP08FP is designed to center a FiberPort inside a 30 mm cage system. The CP08FP secures to the four ER rods of a 30 mm cage assembly. Four #2-56 stainless steel socket head screws are included to secure a FiberPort to the adapter. The CP08FP has internal SM1 threading, enabling it to be used with our extensive line of lens tubes. This plate features a 8-32 tapped hole for post mounting, while the CP08FP/M has an M4 tapped hole for metric compatibility.



Multi-Axis FiberBenches

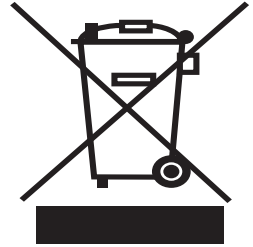
The FiberBench product selection offers platforms with support for three or more wall plates (HCA). Each table is designed so that multiple PAF series FiberPort fiber couplers/collimators can be used to assemble complex systems. An array of holes are positioned on the top surface to allow for the mounting of wave plates, polarizers, beamsplitters, and other optical components without the need for alignment and adjustment. The tables provide a common, compact, and stable platform for optical system designs with parallel and perpendicular beam propagation paths.



Chapter 9 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated



Wheelie Bin Logo

As the WEEE directive applies to self-contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e.g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

9.1. Waste Treatment is Your Own Responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

9.2. Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

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