

# INTERFERENCE MITIGATION SOLUTIONS



# INTRODUCTION

$$\text{SINR}(x) = \frac{P}{I + N}$$

## **SIGNAL**

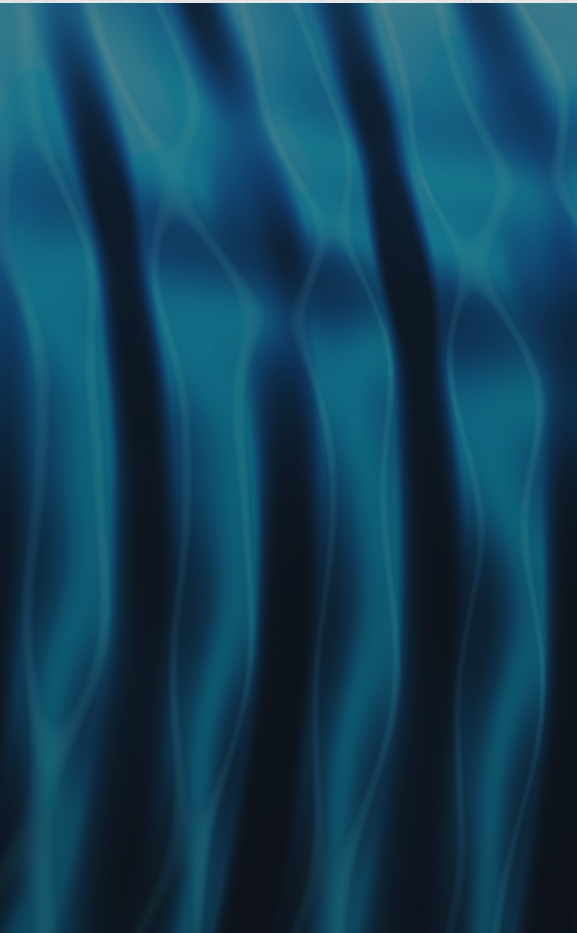
ConcealFab designs and manufactures innovative Small Cell and oDAS concealments that benefit network operators as well as local communities. ConcealFab's aesthetically pleasing solutions enable small cell infrastructure to HIDE IN PLAIN SIGHT®, leading to strong LTE signals in difficult to permit locations.

## **INTERFERENCE plus NOISE**

ConcealFab offers backlobe suppression products to reduce unwanted radiation into adjacent sectors and passive intermodulation mitigation solutions to reduce PIM noise generated by the downlink signals at the site.

## **OPTIMUM PERFORMANCE**

Together, ConcealFab's products and solutions maximize the Signal-to-Interference-plus-Noise Ratio, enabling faster LTE data rates, improved VoIP quality and increased network capacity.



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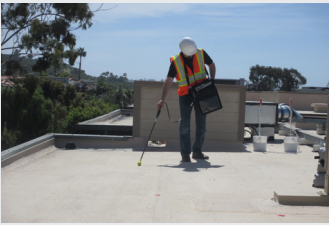


# PASSIVE INTERMODULATION (PIM) - TEST & MEASUREMENT

## OVERVIEW

Passive intermodulation (PIM) is a well-known problem in cellular systems. Downlink signals at the cell site mix at passive, non-linear junctions in the RF path, creating new signals. If these new signals (intermodulation products) fall in an operator's uplink band, they can elevate the noise floor and degrade system performance.

RF equipment manufacturers have spent decades developing methods to improve the PIM performance of the RF components in antenna feed systems. Unfortunately, a low PIM feed system by itself does not guarantee that a site will perform to expectations. PIM sources beyond the antenna are now often the limiting factor for site PIM performance.



## TEST PROCESS

ConcealFab is the world leader in external PIM mitigation solutions and has developed the necessary tools, materials and measurement processes required to achieve success.

- 1 MEASURE**  
Measure the beginning PIM level and estimate Distance-to-PIM (DTP) using a portable PIM analyzer.
- 2 LOCATE**  
Precisely locate all external PIM sources using a PIM Probe attached to a spectrum analyzer tuned to the IM3 frequency.
- 3 COVER**  
Temporarily cover PIM sources with PIM blankets to observe the level of benefit that can be achieved.
- 4 REPAIR**  
Permanently install PIM Shield™ products at the locations identified to suppress PIM and improve site performance.



## CERTIFICATION TRAINING

ConcealFab offers an intense one-day instructor led training course to teach wireless professionals how to precisely locate and mitigate external PIM at cell sites. The course uses a combination of theory and practical, hands-on exercises to build user confidence.



## PIM PROBE

Part number: 007320-01

The PIM test probe is used in conjunction with other test and measurement equipment to precisely locate external PIM sources in the field. Once PIM locations are identified, mitigation materials available from ConcealFab can be applied to reduce the PIM levels and improve site performance.

### KEY FEATURES

- Wide frequency bandwidth (600 MHz to 2700 MHz)
- Low PIM when exposed to RF radiation
- PIM magnitude insensitive to probe orientation
- Rugged construction



## PIM BLANKETS

ConcealFab's PIM blankets are temporary RF barriers that can be deployed to help isolate sources of passive intermodulation (PIM). When a PIM blanket is placed over an external PIM source, PIM from that source is typically reduced by >30 dB.

### KEY FEATURES

- Low PIM
- High RF attenuation
- Heavy duty vinyl construction
- Integrated tie-down loops (see table)



Part Number	Length	Width	Loops	Corners
007640-120060	120 in (3.05 m)	60 in (1.52 m)	6	Rounded
007640-060060	60 in (1.52 m)	60 in (1.52 m)	4	Rounded
007640-060030	60 in (1.52 m)	30 in (0.75 m)	4	Rounded
007640-030030	30 in (0.75 m)	30 in (0.75 m)	4	Rounded

For custom sizes please contact ConcealFab customer service, + 1 719 599 3400



## PIM BLANKET KITS

Assorted PIM blankets supplied inside heavy duty transit case.

Part Number	Description	Weight
007640-KIT-101	PIM Blanket Kit, 2x 120x60, 2x 60x60, 2x 60x30, 2x 30x30	76 lbs
007640-KIT-102	PIM Blanket Kit, 3x 120x60, 2x 60x60	79.5 lbs
007640-KIT-103	PIM Blanket Kit 4x 120x60	79.5 lbs
007640-KIT-104	PIM Blanket Kit 8x 60x60	79.5 lbs
007640-KIT-201	PIM Blanket Kit 4x 120x60, 4x 60x60, 4x 60x30, 4x 30x30	142 lbs
007640-KIT-202	PIM Blanket Kit, 6x 120x60, 3x 60x60	140 lbs
007640-KIT-203	PIM Blanket Kit, 5x 120x60, 5x 60x60	134 lbs



# PASSIVE INTERMODULATION (PIM) - MITIGATION

## OVERVIEW

PIM Shield™ is a family of products developed by ConcealFab that reduce external PIM at cell sites. Barrier products are available that eliminate PIM by preventing downlink signals from reaching PIM sources at the site. Cable support products are available that eliminate PIM by preventing loose metal-to-metal contacts. PIM Shield™ products are designed to withstand harsh environments, providing long term PIM protection.

## PIM SHIELD™ TAPE

PIM Shield™ tape is a rapidly deployable RF barrier able to bond to a wide variety of surfaces including metals, single-ply roofing, multi-ply roofing, concrete, brick and wood. The tape's highly compliant synthetic resin adhesive enables strong bonds to irregular surfaces. See installation instructions for surface preparation requirements.

PIM tape should only be installed by certified contractors using a PIM Probe to identify the exact PIM source locations. It is highly recommended that contractors install a PIM blanket over the suspect area to verify PIM reduction before applying PIM tape. Once applied, the tape is impossible to reposition and extremely difficult to remove.

## KEY FEATURES

- Low PIM
- High RF attenuation
- UV stable TPO outer protective layer
- High tack synthetic resin adhesive
- Silicone release liner

Part Number	Roll Width	Roll Length	Color
008587-06-25-W	6 in	25 ft	White
008587-06-25-B	6 in	25 ft	Black
008587-12-25-W	12 in	25 ft	White
008587-12-25-B	12 in	25 ft	Black



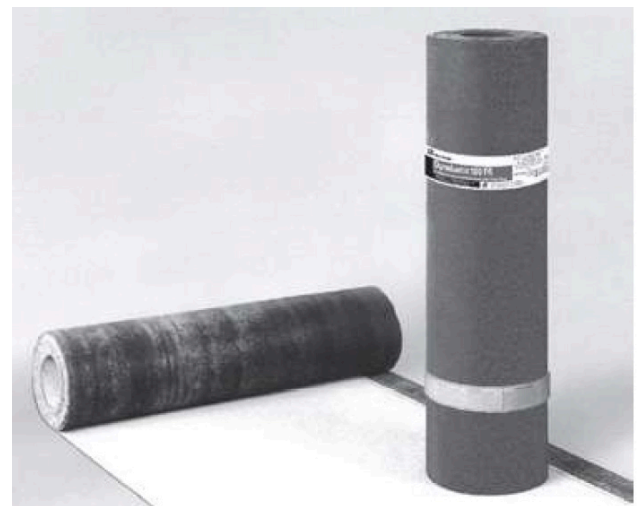
## PIM SHIELD™ ROOFING



ConcealFab has partnered with Johns Manville, a global leader in the roofing industry, to co-develop reliable roofing materials able to mitigate passive intermodulation at cell sites. These materials are particularly useful at reducing PIM on sites where the base station antennas are recessed from the building edge due to zoning restrictions.

PIM Shield™ roofing is a multi-ply Styrene-Butadiene-Styrene (SBS) modified bitumen roof membrane manufactured by Johns Manville and sold exclusively through ConcealFab. The material includes ceramic coated granules on the top surface for solar reflectivity and membrane protection. An internal PIM Shield™ layer bonded between two SBS modified bitumen layers form a water-tight RF barrier able to provide decades of PIM protection. The material can be installed using industry standard hot asphalt or cold adhesive processes. PIM Shield™ roofing complies with applicable ASTM standards and carries both UL and FM approvals.

To maintain an existing or to be eligible for a new JM Peak Advantage Guarantee, the PIM Shield™ roofing material must be installed by a JM certified contractor who is approved for SBS Modified Bitumen Roofing Systems. Please contact ConcealFab customer service or JM Technical Services for additional information related to roofing guarantees.



Part Number	Description	Granules	Application Method
DL180FRPIM	DynaLastic 180 FR PIM, 10 m x 1 m roll	S	HA, CA
DL180FRCRGPIM	DynaLastic 180 FR CR G PIM, 10 m x1 m roll	HR	HA, CA

Granules: S = Standard, HR = High Reflectivity

Application Method: HA = Hot Asphalt, CA = Cold Adhesive





# PASSIVE INTERMODULATION (PIM) - MITIGATION

## LOW PIM CABLE SUPPORT SYSTEMS

Loose metal-to-metal contacts and dissimilar metal junctions have been found to cause service effecting PIM when located in the reactive near field around base station antennas. This “High-Risk PIM Zone” extends multiple wavelengths above, below and behind the antenna into areas commonly used for securing RF components. Traditional mounting hardware such as hose clamps and metal snap-in hangers can generate high levels of PIM and must be avoided in the “High-Risk PIM Zone.”

To address this problem, ConcealFab has partnered with FIMO, a global leader in cable support systems, to develop a family of low PIM cable support products that can be reliably deployed in the “High-Risk PIM Zone.” Each design has been thoroughly tested in accordance with IEC 62037-8 (Radiated PIM test) to verify low PIM performance.

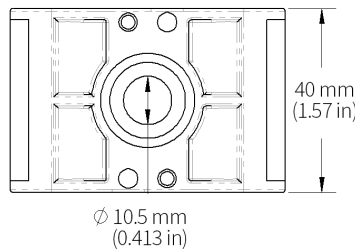
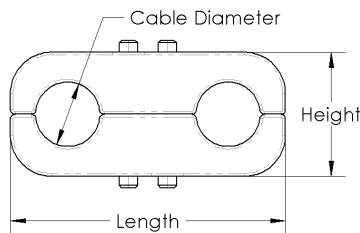
### KEY FEATURES

- No dissimilar metal junctions
- PIM eliminated by high clamping force
- PIM eliminated with plastic insulation



## CABLE SUPPORT BLOCKS

When supported and installed correctly, Cable Support Blocks provide a reliable, low PIM method for securing cables at cell sites. ConcealFab offers high strength, UV stable Cable Support Blocks that securely grip two cables without deforming the outer RF conductor. Cable Support Blocks are often selected for high wind zones due to their superior strength and rigid support.



Part Number	Description	Cable Diameter (mm)	Height	Length
PSCB-0405-10	PIM Shield Cable Block, 4.5 to 5.5 mm	4.5 – 5.5	16 mm (0.63 in)	42 mm (1.65 in)
PSCB-0608-10	PIM Shield Cable Block, 6 to 8 mm	6.0 – 8.0	20 mm (0.79 in)	51 mm (2.01 in)
PSCB-0809-10	PIM Shield Cable Block, 8 to 9 mm	8.0 – 9.0	20 mm (0.79 in)	51 mm (2.01 in)
PSCB-1011-10	PIM Shield Cable Block, 10 to 11 mm	10.0 – 11.0	20 mm (0.79 in)	51 mm (2.01 in)
PSCB-1213-10	PIM Shield Cable Block, 12 to 13 mm	12.0 -13.0	27 mm (1.06 in)	60 mm (2.36 in)
PSCB-1314-10	PIM Shield Cable Block, 13 to 14 mm, (1/2 in Hi-Flex)	13.0 – 14.0	27 mm (1.06 in)	60 mm (2.36 in)
PSCB-1517-10	PIM Shield Cable Block, 15.5 to 17 mm, (1/2 in)	15.5 – 17.0	27 mm (1.06 in)	60 mm (2.36 in)
PSCB-2123-10	PIM Shield Cable Block, 21 to 23 mm, (5/8 in)	21.0 – 23.0	37 mm (1.46 in)	84 mm (3.31 in)
PSCB-2728-10	PIM Shield Cable Block, 27 to 28 mm, (7/8 in)	27.0 – 28.0	37 mm (1.46 in)	84 mm (3.31 in)
PSCB-3940-10	PIM Shield Cable Block, 39 to 40 mm, (1-1/4 in)	39.0 – 40.0	54 mm (2.13 in)	108 mm (4.25 in)
PSCB-5052-10	PIM Shield Cable Block, 50 to 52 mm, (1-5/8 in)	50.0 – 52.0	66 mm (2.60 in)	133 mm (5.24 in)

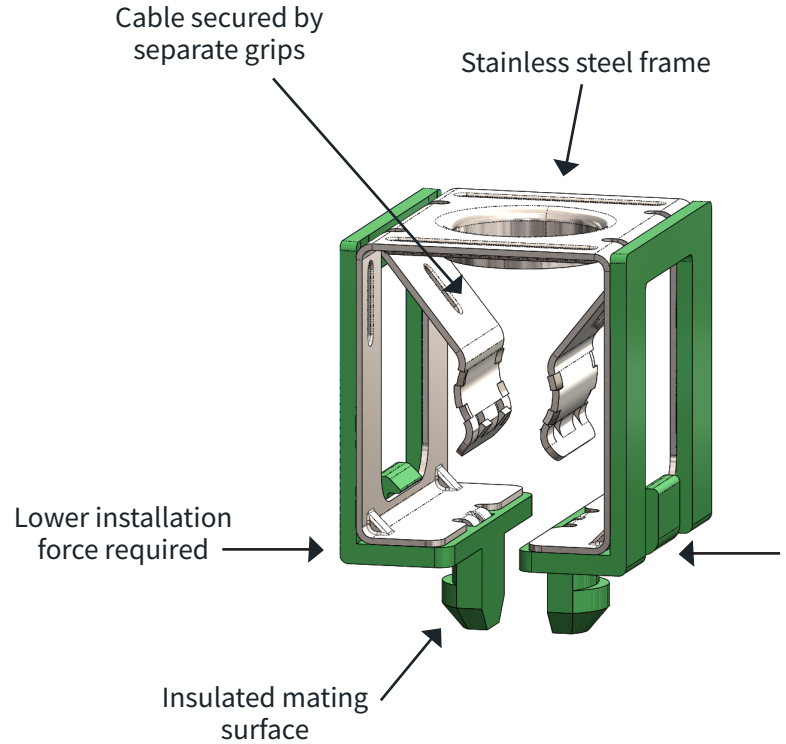
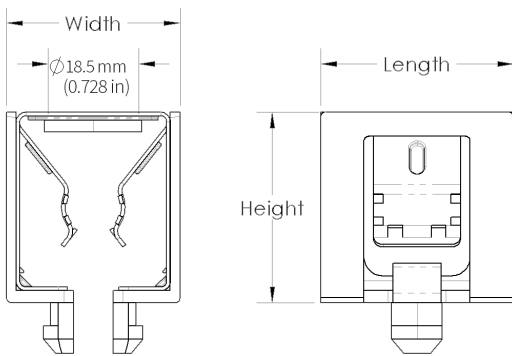
Sold in bags of 20 halves to make 10 Cable Support Blocks

## HYBRID METAL / PLASTIC SNAP-INS

Traditional metal snap-in hangers provide fast assembly but generate high levels of PIM at the contacting surfaces between hangers and at the hanger attachment interface. ConcealFab’s Patent Pending “Hybrid” snap-in design provides insulation at the mating interfaces to prevent metal-to-metal contact. “Hybrid” snap-ins deliver low PIM performance along with the strength and installation ease of FIMO’s patented snap-in design.

### KEY FEATURES

- High strength
- Low PIM
- Easy to install / remove / reposition
- No tools required
- 360° rotation at mounting interface



Part Number	Description	Cable Diameter	Height	Length	Width
PSHS-1319-10	PIM Shield Hybrid Snap-In, 13 to 19 mm (1/2 in)	13 to 19 mm	40 mm (1.57 in)	40 mm (1.57 in)	36 mm (1.42 in)
PSHS-2630-10	PIM Shield Hybrid Snap-In, 26 to 30 mm (7/8 in)	26 to 30 mm	40 mm (1.57 in)	40 mm (1.57 in)	36 mm (1.42 in)

Sold in bags of 10

### CABLE CUSHIONS

Cable Cushions are available that fit inside ConcealFab’s “Hybrid” snap-ins to support smaller diameter RET, DC power, grounding and fiber optic cables. These cushions fit securely inside the “Hybrid” snap-in and do not fall out while securing cables. Cable Cushions are color-coded for easy identification and inspection.



Part Number	Description	Cable Diameter (mm)	Install inside Hybrid Snap-In	Color
PSCC-1001-10	PIM Shield Cable Cushion, 4.5 to 6.5 mm	4.5 – 6.5	PSHS-1319-10	Blue
PSCC-1002-10	PIM Shield Cable Cushion, 6.6 to 8.5 mm	6.6 – 8.5	PSHS-1319-10	Gray
PSCC-1003-10	PIM Shield Cable Cushion, 8.6 to 10.5 mm	8.6 – 10.5	PSHS-1319-10	Black
PSCC-2001-10	PIM Shield Cable Cushion, 10.6 to 12.5 mm	10.6 – 12.5	PSHS-2630-10	Orange

Sold in bags of 10

# PASSIVE INTERMODULATION (PIM) - MITIGATION

## HYBRID SNAP-IN MOUNTING SYSTEMS

ConcealFab offers a variety of low PIM mounting systems that are optimized for use with “Hybrid” snap-ins. Options are available for both high and low cable count locations that enable low PIM mounts to be placed where they are needed for optimum cable routing.

## LOW CABLE COUNT LOCATIONS

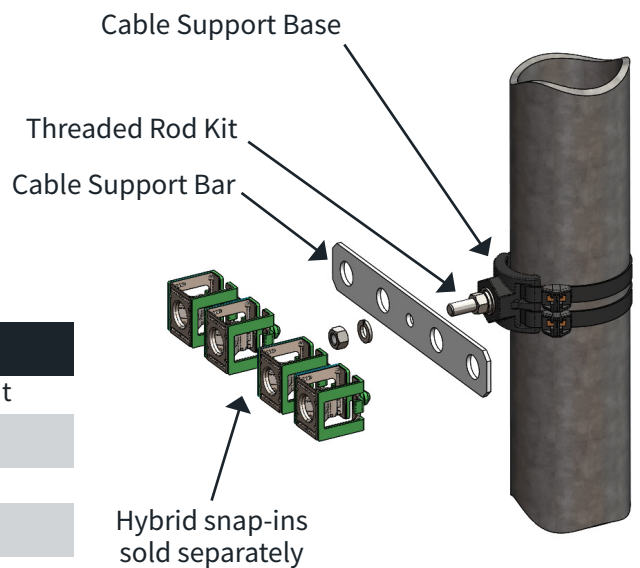
ConcealFab’s Patent Pending cable support base provides a low PIM method to secure stainless steel cable support bars to structural members at a cell site. The UV stable plastic support base is designed to be secured using 1/2 inch wide Deltec® cable ties from Thomas & Betts (or equivalent), eliminating all metal-to-metal contact at the attachment interface.

### KEY FEATURES

- Low PIM
- Fast Installation
- Stainless steel support bar
- Provides 4 “Hybrid” snap-in support points

Part Number	Description
900209-10	PIM Shield Cable Support Base with Large Head Nut
900210-10	PIM Shield Threaded Rod Kit, 3/8” x 2 in
900351-10	PIM Shield Cable Support Bar, 4 Position
900053	Torque Wrench, Fixed, 9/16 in Head, 10 ft-lb

*Sold in kits of 10, Torque wrenches sold individually*

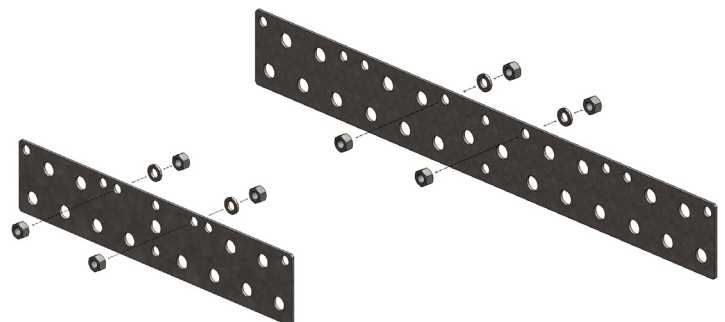


## HIGH CABLE COUNT LOCATIONS

ConcealFab offers simple, highly configurable mounting systems for securing large quantities of cables to round structural members at a cell site. The all galvanized steel construction with high clamping force provides consistent low PIM performance. Two different threaded rod lengths are available for placing support bars at varying distances from the pipe. Extra bar kits can be purchased and installed as needed.

### KEY FEATURES

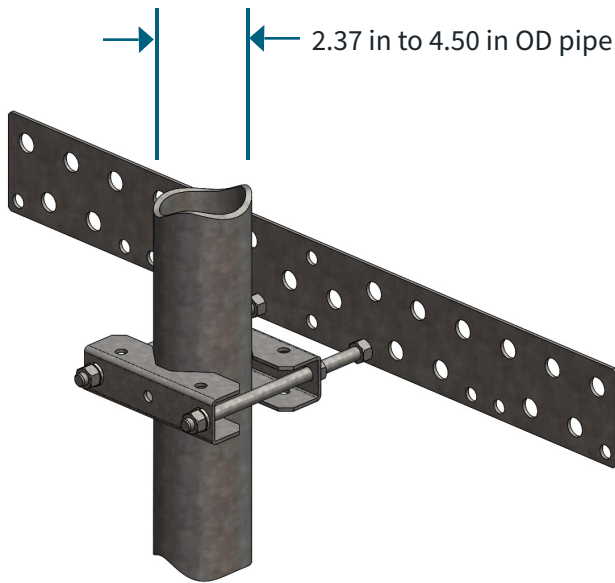
- Low PIM
- Highly configurable
- Galvanized steel construction
- Up to 22 “Hybrid” snap-in support points



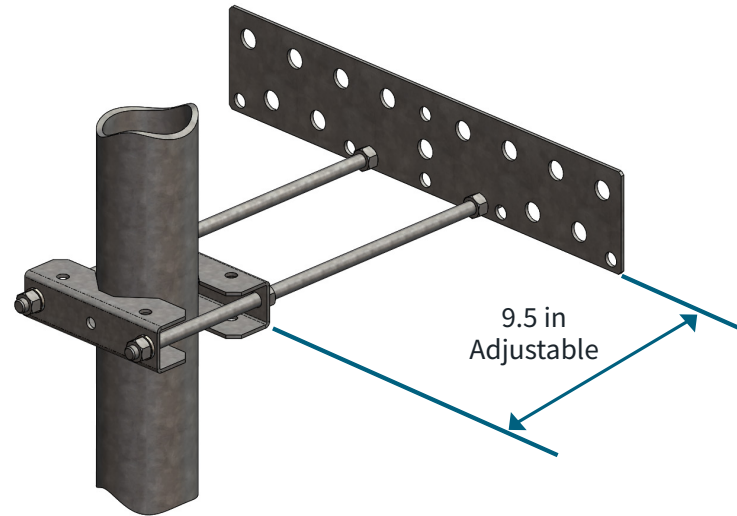
**13-Position Bar Kit (19.0 in)**

**22-Position Bar Kit (30.5 in)**

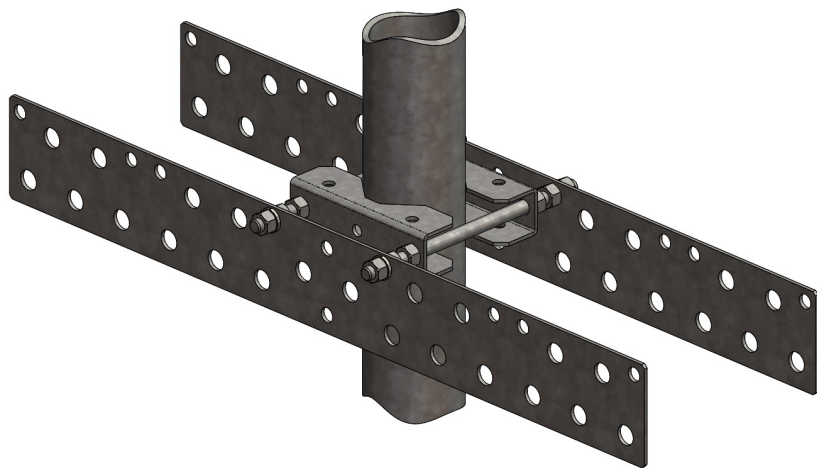




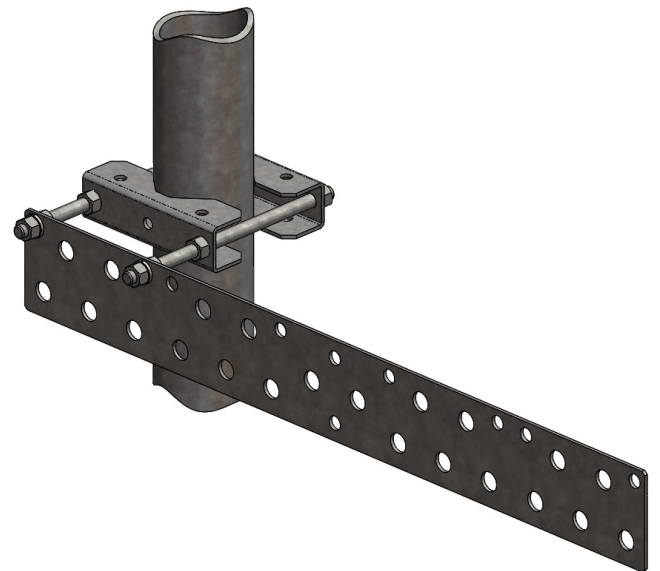
**22-Position Pole Mount Kit**



**13-Position Extended Range Pole Mount Kit**



**22-Position Pole Mount Kit with Bar Kit installed**



**22-Position Pole Mount Kit installed in "Flag" configuration**

Part Number	Description
900352-01	PIM Shield Cable Support Bar, Pole Mount Kit, 13-Position
900352-02	PIM Shield Cable Support Bar, Pole Mount Kit, 13-Position, Extended Range
900353-01	PIM Shield Cable Support Bar, Pole Mount kit, 22-Position
900353-02	PIM Shield Cable Support Bar, Pole Mount kit, 22-Position, Extended Range
900354	PIM Shield Cable Support, Extra Bar Kit, 13-Position
900355	PIM Shield Cable Support, Extra Bar Kit, 22-Position

# PASSIVE INTERMODULATION (PIM) - MITIGATION

## CABLE SUPPORT BLOCK MOUNTING SYSTEMS

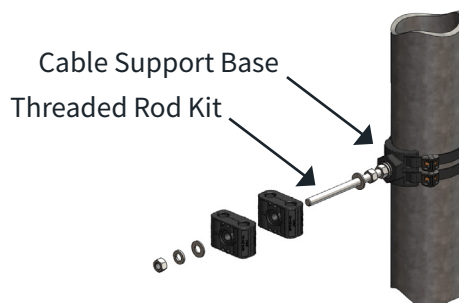
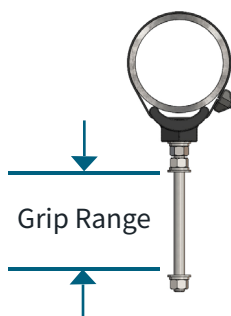
ConcealFab also offers a variety of low PIM mounting systems for use with Cable Support Blocks. Options are available for both high and low cable count locations that enable low PIM mounts to be placed where needed for optimum cable routing.

### LOW CABLE COUNT LOCATIONS

ConcealFab's Patent Pending Cable Support Base provides a low PIM method to secure 3/8 inch stainless steel threaded rods to structural members at a cell site. The UV stable plastic support base is designed to be secured using 1/2 inch wide Deltec® cable ties from Thomas & Betts (or equivalent), eliminating all metal-to-metal contact at the attachment interface.

#### KEY FEATURES

- Low PIM
- Fast Installation
- Secures 3/8 inch SS threaded rod
- Supports up to 6 cables



Part Number	Description	Grip Range
900209-10	PIM Shield Cable Support Base with Large Head Nut	n/a
900211-10	PIM Shield Threaded Rod Kit, 3/8 in x 6 in	89 mm (3.50 in)
900212-10	PIM Shield Threaded Rod Kit, 3/8 in x 8 in	140 mm (5.50 in)

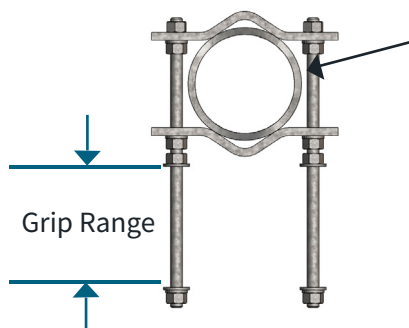
*Sold in kits of 10*

### LOW CABLE COUNT LOCATIONS – HEAVY DUTY

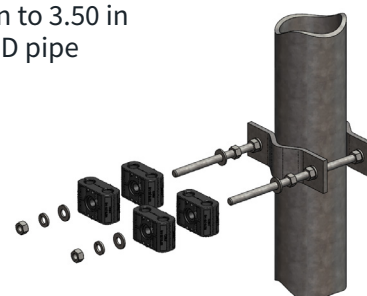
ConcealFab offers heavy duty galvanized steel support brackets for securing Cable Support Blocks to antenna mounting pipes. The kit includes galvanized threaded rods and galvanized hardware to eliminate all dissimilar metal contacts. Kits are available with different threaded rod lengths based on the grip range desired.

#### KEY FEATURES

- Low PIM
- Galvanized steel construction
- Supports up to 12 cables



2.37 in to 3.50 in  
OD pipe



Part Number	Description	Grip Range
009718-01-10	PIM Shield Cable Support Bracket, Small	32 mm (1.25 in)
009718-02-10	PIM Shield Cable Support Bracket, Large	95 mm (3.75 in)
900053	Torque Wrench, Fixed, 9/16 in Head, 10 ft-lb	n/a

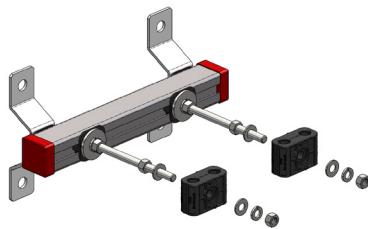
*Brackets sold in kits of 10, Torque wrenches sold individually*

## HIGH CABLE COUNT LOCATIONS – RAIL SYSTEM

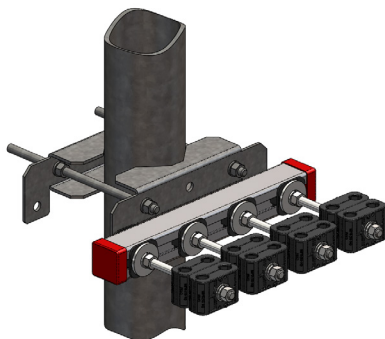
ConcealFab has developed a Patent Pending rail system for supporting large quantities of Cable Support Blocks at cell sites. The system includes an extruded aluminum rail with molded channel runners that insulate mounting hardware from the rail. The system works with ConcealFab’s 3/8 inch stainless steel Threaded Rod Kits and can be configured to support a wide variety of mounting scenarios.

### KEY FEATURES

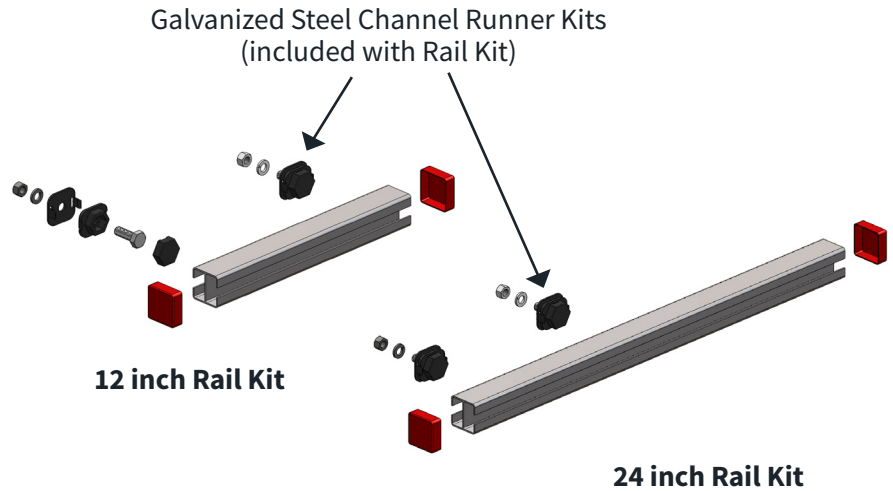
- Low PIM
- Highly configurable
- Easy to adjust cable block location
- Extruded aluminum rail
- Galvanized steel mounting bracket



**12 inch Rail Kit plus Wall Mount Brackets**

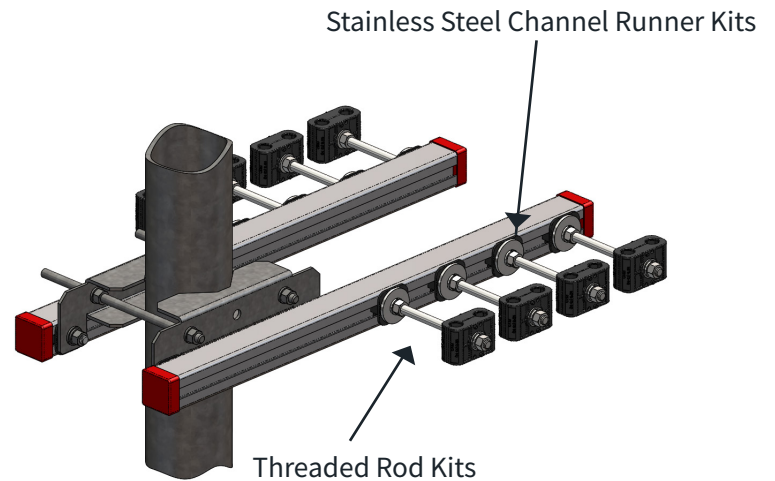


**12 inch Pole Mount Kit**



**12 inch Rail Kit**

**24 inch Rail Kit**



**24 inch Pole Mount Kit plus extra Rail Kit deployed in “Flag” configuration**

Part Number	Description
900356	PIM Shield Cable Support Rail, Pole Mount Kit, 12 in
900357	PIM Shield Cable Support Rail, Pole Mount Kit, 24 in
900359-12	PIM Shield Rail Kit, 12 in
900359-24	PIM Shield Rail Kit, 24 in
900362-10	PIM Shield Channel Runner Kit, SS, 3/8 in
900360-10	PIM Shield Channel Runner Kit, Galvanized, M10 x 30mm
900361	PIM Shield Cable Support Rail, Wall Mount Brackets

Channel Runner kits sold in kits of 10





## OVERVIEW

In a perfect LTE system, each mobile in a sector would only receive a strong signal from the base station antenna designated to serve that sector. The signal from one sector should be dominant all the way to the edge of coverage, then rapidly decay as the mobile moves across the sector boundary. In the real world, this is very difficult to achieve. In many cases signals from adjacent or even distant sectors can arrive stronger than desired within the coverage area, creating interference and causing unwanted hand-offs. This is particularly challenging in stadium applications which may include more than 50 sectors within a single venue.

Engineers designing a cellular system use directional base station antennas to focus energy into the desired area of coverage. An ideal base station antenna would only radiate energy where intended and radiate no energy in unwanted directions. Unfortunately, that is not possible (or practical) given the size and cost constraints placed on base station antenna manufacturers. Unwanted side and backlobe radiation often occurs at lower frequencies where the physical size of the antenna is small with respect to a wavelength.

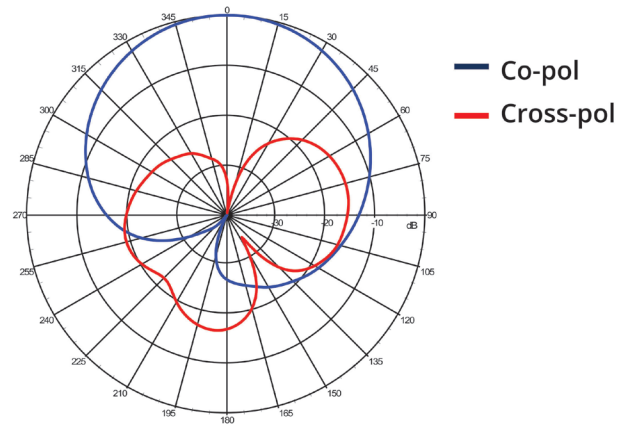
To combat undesired backlobe radiation, ConcealFab has developed surface wave suppression technology that can be applied to existing base station antennas. The suppressors are built onto an aluminum frame and coated with polyurethane (truck bed liner) for environmental protection. Hardware is provided to attach the suppressor between the antenna and its existing pole mounting hardware. Due to size and physical mounting differences, a unique backlobe suppressor design is required for each different antenna model.

# BACKLOBE SUPPRESSION

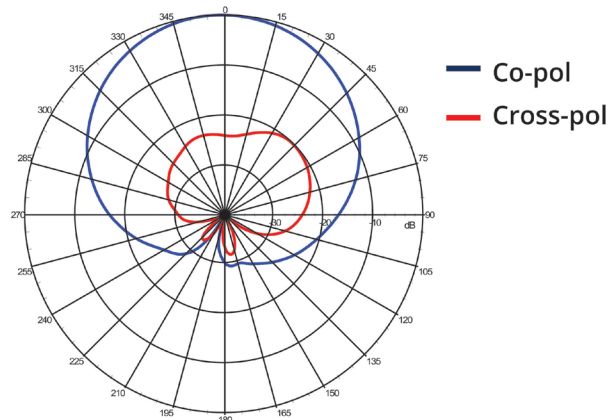
While results will vary from antenna model to antenna model and from frequency to frequency, the plots below are representative of the performance improvements typically achieved. The blue plots represent the far field, co-polarized radiation patterns and the red plots represent the far field, cross-polarized radiation patterns. Here, the front-to-back ratio, measured within the 30° cone behind the antenna improved from 16 dB to 28 dB with the BackLobe Suppressor installed.

As is typical with most  $\pm 45^\circ$  polarized antennas, cross-pol radiation in the lower frequency bands is often higher than the level indicated in the planning tool patterns. This is not due to antenna manufactures trying to hide information. Rather, it is due to the accepted industry standard that planning tool patterns are derived from co-polarized radiation patterns rather than total energy radiation patterns. While co-pol patterns may be perfectly adequate for predicting performance at typical macro sectors, they may not adequately predict performance at tightly spaced stadium sectors. ConcealFab's Backlobe Suppressors provide an effective way to clean-up unwanted backlobe radiation when predicted performance does not match actual performance.

## 698 MHz - Without Backlobe Suppressor



## 698 MHz - With Backlobe Suppressor





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