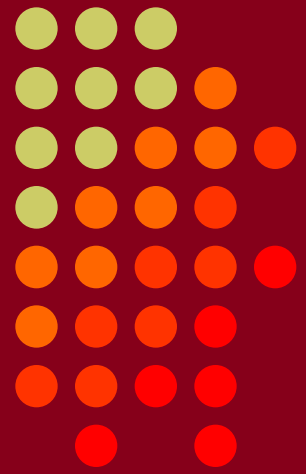
Improving the Performance of your 40 through 10 Meter Antennas

- Horizontally polarized antennas
- Single Yagi stations
- Single tower stations
- Stacked Yagis
- Care and feeding of coaxial cables



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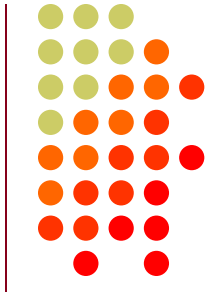
6 dB of “Free” Ground Gain

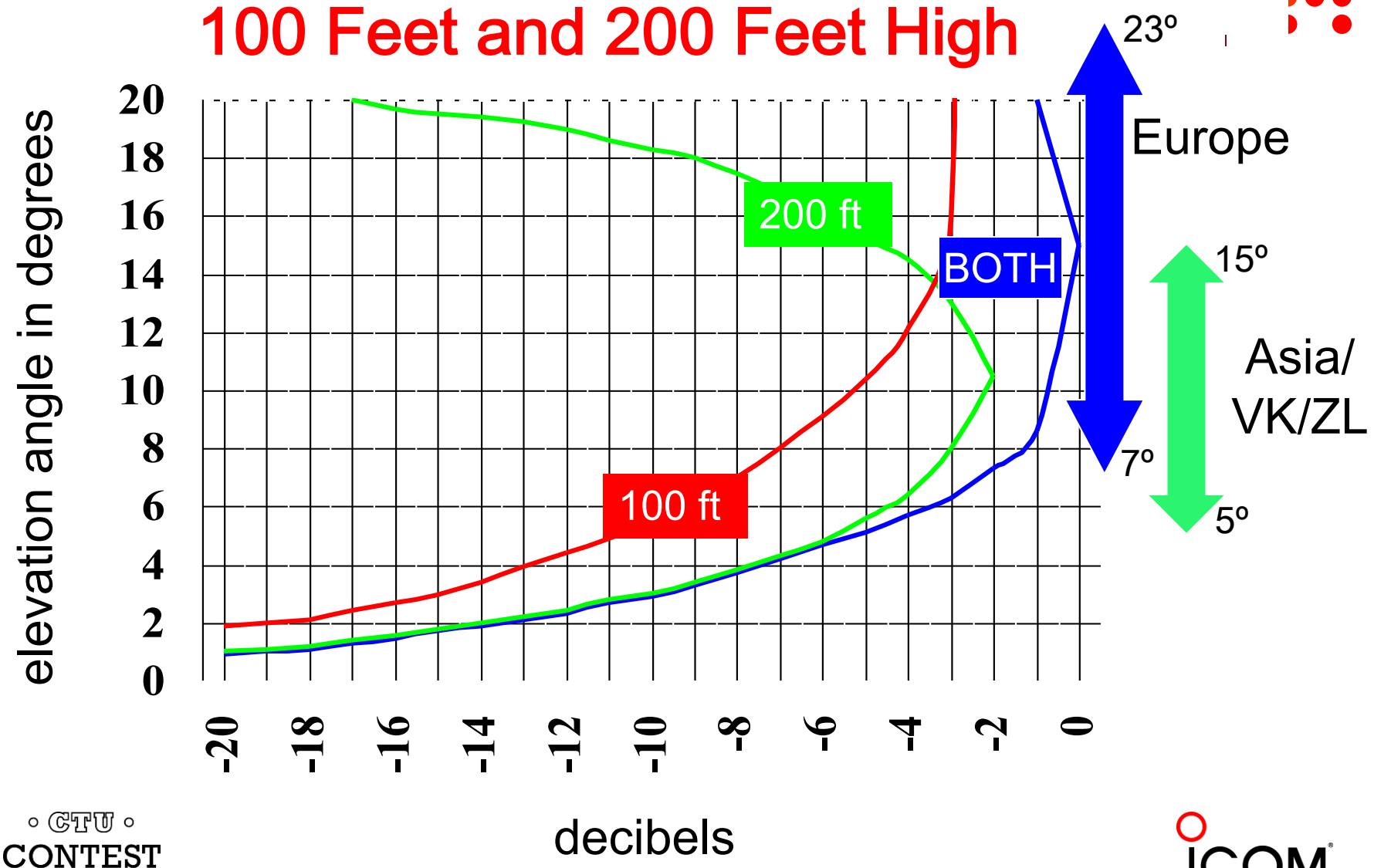
- A horizontally polarized dipole, Yagi or quad easily provides 6 dB of useful ground gain
  - but only if you install it an appropriate height
  - vertical antennas can achieve equivalent ground gain only over highly conductive soil such as a salt marsh
- Stacked HF Yagis achieve higher gain mainly by suppressing undesired high angle radiation and redistributing the power into the main low angle beam
  - stacked Yagis must be installed at appropriate heights to achieve the expected results

High Performance Antennas for 40 Meters

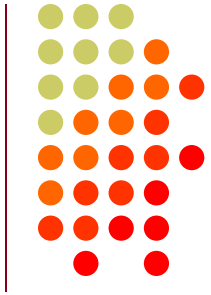


- High horizontal dipole at least 70 feet high for DX contests
  - otherwise use a four-square vertical array with 30-60 radials
  - use a dipole at 40-50 feet high for Sweepstakes and Field Day
- Higher gain: 2 element Yagi at 70-100 feet high
  - significant improvement over a simple horizontal dipole for DX
  - a Cushcraft XM-240 at 70-100 feet high is very cost effective
- Highest gain: full size 3 element Yagi at 100-140 feet high
  - but don't underestimate the high cost and complexity of the effort !
- High performance 40 meter receiving antennas
  - 200 foot Beverages
  - arrays of 14 foot verticals

Stacked 3 Element 40 Meter Yagis
48 Foot Booms
100 Feet and 200 Feet High



4-Square Vertical Array for 40 Meters



- A 4-square vertical array is good alternative to a Yagi if you cannot install it at least 70 feet high.
  - install a 4-square at least 40 feet from all other towers
    - more spacing will significantly improve its performance
  - at least 30-60 slightly buried 35 foot radials under each vertical
- A 4-square is an excellent receiving antenna

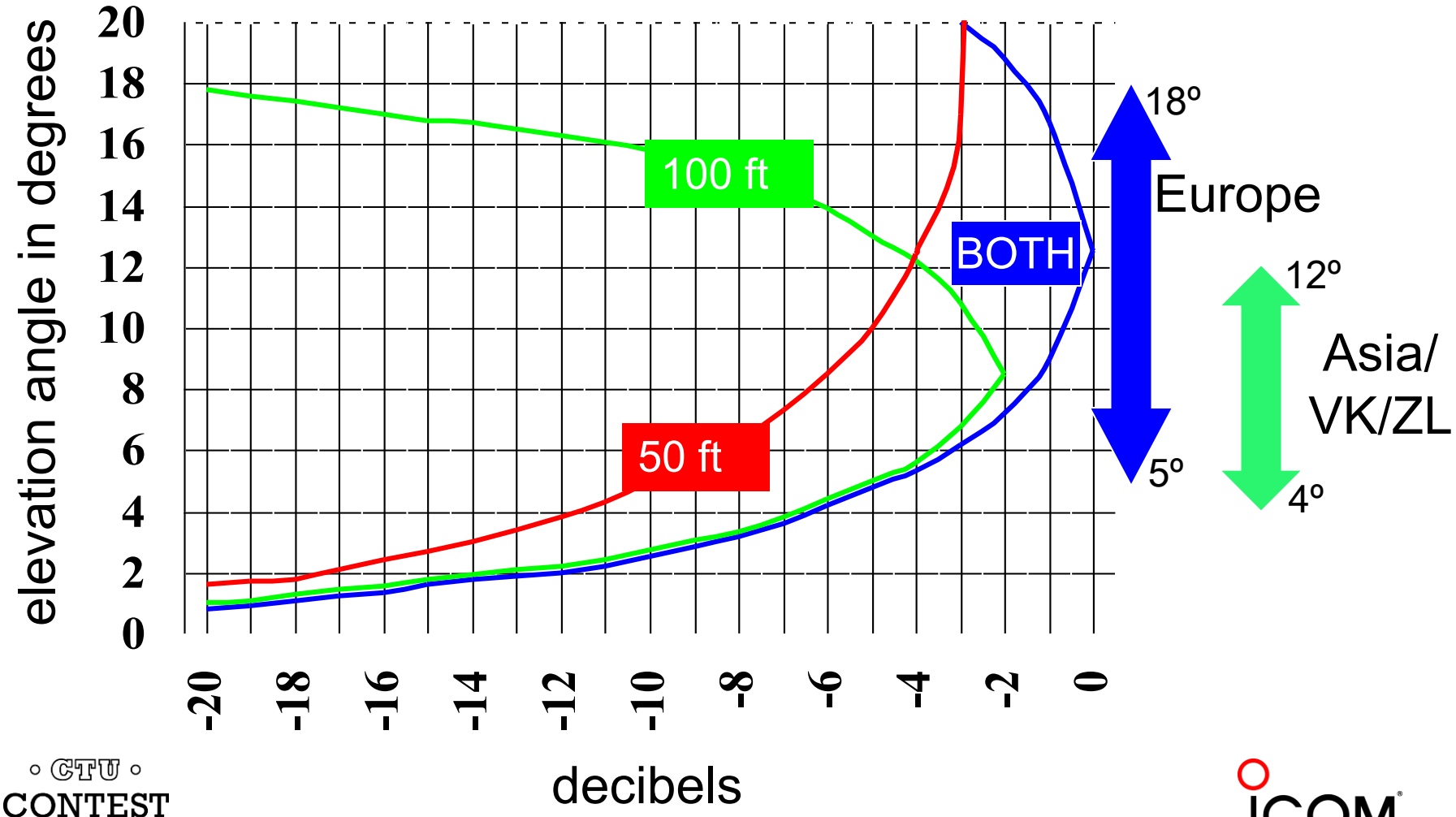
The Comtek 4-Square Controller

www.dxengineering.com/search/brand/comtek

High Performance Antennas for 20 Meters

- A horizontal Yagi or quad is always the best choice
  - if you can install your antenna at 35 feet high or higher
  - otherwise use a four-square vertical array with 30-60 radials
- Moderate gain: small tri-band Yagi, Hex-beam or quad
  - a small Yagi at 50-70 feet high will produce good DX results
  - a small Yagi at 35-50 feet high for Sweepstakes and Field Day
- High gain: full size tri-band Yagi, small monoband Yagi or quad at 70-100 feet high for excellent DX results
- Highest gain: two stacked monoband Yagis on a 100-140 foot tower (170-200 feet high for three stacked Yagis)
  - stack switching (a “stackmatch”) provides high payoff at low cost

Stacked 5 Element 20 Meter Yagis
48 Foot Booms
50 and 100 Feet High



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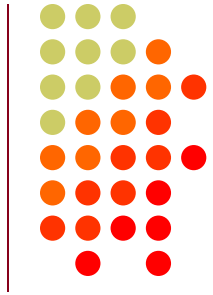
The Array Solutions Stack Match

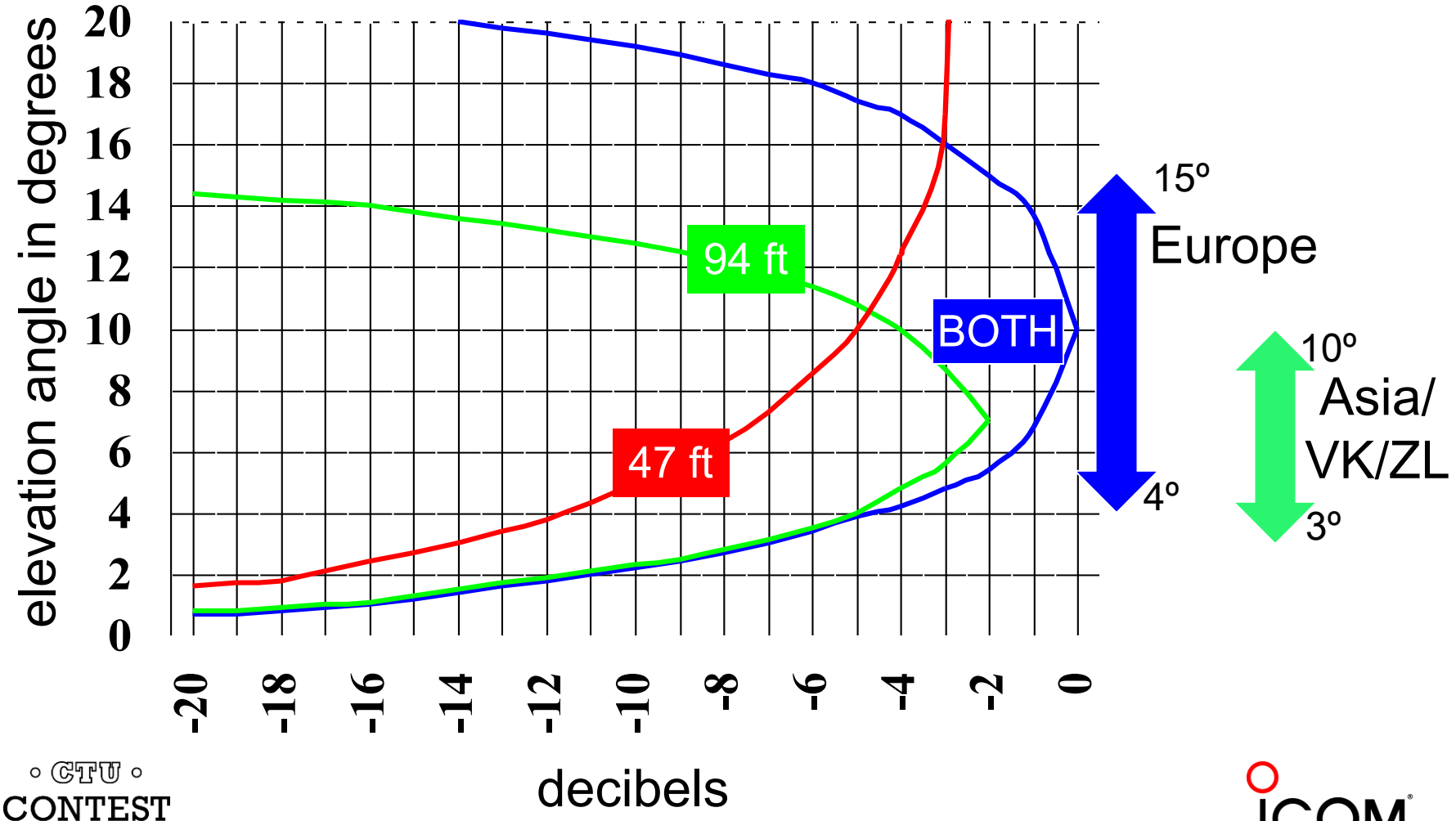
www.arraysolutions.com/Products/stackmatch.htm

High Performance Antennas for 15 Meters

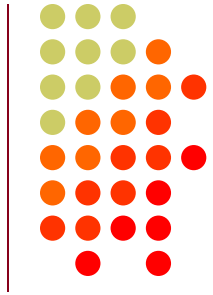


- Horizontal polarization is always the best choice
  - if you can install your antenna 35 feet high or higher
  - otherwise use a four-square vertical array with 30-60 radials
- Moderate gain: small tri-bander Yagi, Hex-beam or quad
  - a small Yagi at 40-50 feet high will produce good DX results
  - a small Yagi at 30-50 feet high for Sweepstakes and Field Day
- High gain: a full size tri-band Yagi, small monoband Yagi or quad at 70-90 feet high for excellent DX results
- Highest gain: two stacked monoband Yagis on a 80-100 foot tower (120-140 feet high for three stacked Yagis)
  - stack switching (a “stackmatch”) provides high payoff at low cost

Stacked 6 Element 15 Meter Yagis
48 Foot Booms
47 and 94 Feet High

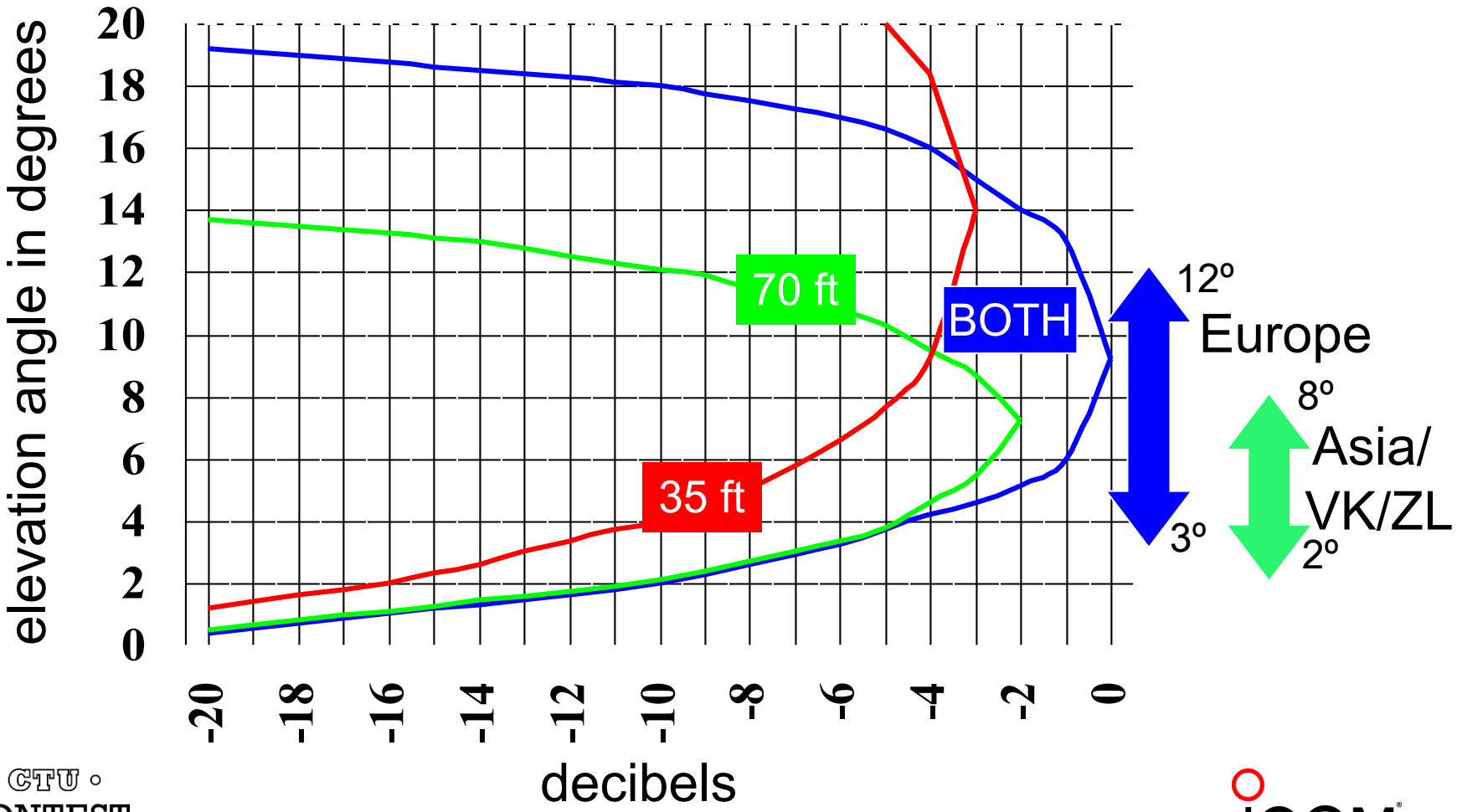


High Performance Antennas for 10 Meters

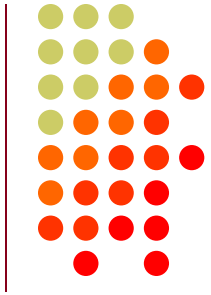


- Horizontal polarization is always your best choice
  - if you can install your antenna only 25 feet high or higher
  - otherwise use a four-square vertical array with 30-60 radials
- Moderate gain: small tri-band Yagi, Hex-beam or quad
  - a small Yagi 25-50 feet high will produce good results
  - a small Yagi at 25-40 feet high for Sweepstakes and Field Day
- High gain: a full size tri-band Yagi, small monoband Yagi or quad, at 50-70 feet high for excellent DX results
- Highest gain: two stacked monoband Yagis on a 60-70 foot tower (90-120 feet high for three stacked Yagis)
  - stack switching (a “stackmatch”) provides high payoff at low cost

Stacked 6 Element 10 Meter Yagis
36 Foot Booms
35 and 70 Feet High

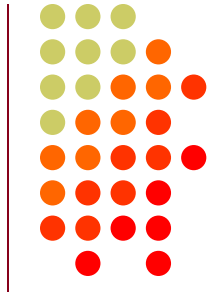


Competitive One Tower Antenna Systems



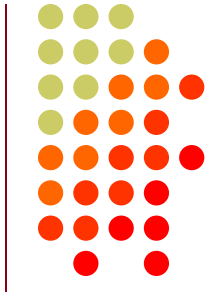
- 50-60 foot tower and a small rotator (e.g., HyGain Ham-IV)
  - small tri-band Yagi, Hex-beam or quad
  - 40 and 80 meter dipoles and a 160 meter inverted-L
- 70-80 foot tower and a medium rotator (e.g. HyGain T2X)
  - Cushcraft XM-240 two element 40 meter Yagi
  - large tri-band Yagi such as the DX Engineering Skyhawk
  - 80 meter dipole and a 160 meter inverted-L
- 100-140 foot tower and a large rotator (e.g., M2 Orion)
  - Cushcraft XM-240 two element 40 meter Yagi
  - monoband Yagis such as the Hy-Gain LJ series on ring rotators
  - 80 meter dipole and a 160 meter inverted-L

Achieving and Maintaining Low Loss Coaxial Cables



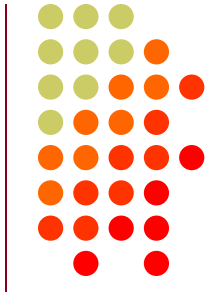
- Select appropriate low loss coaxial cables for each antenna
- Preserve your investment
  - water and moisture entry is a persistent, serious threat to your station
- Hard-line (e.g., Heliax or 75 ohm CATV) coaxial cables are the best choice for cable runs longer than 100 feet
  - RG-213 and all other flexible jacket coaxial cables are very susceptible to physical damage and water entry
    - a pin hole in the jacket can quickly cause a high loss cable
    - carefully protect your coax cables from physical damage and water entry
- Assure long term performance
  - test and inspect your cables and connectors at least annually

Coaxial Cable Monetary Considerations



- The selection, installation and maintenance of coaxial cables and connectors should be among your most important investments when building and improving your competitive station
  - Is the proper grade of coaxial cable worth your additional cost?
  - Is attention to the many details of installation worth your extra effort?
  - Is annual inspection to preserve your investment worth your effort?
- Yes
  - If you want trouble-free low loss coax cables for 25 years or longer
- No
  - If you don't mind the high cost and disappointment of catastrophic failure when you least expect it

Coaxial Cable Environmental Considerations



- Constant exposure to wind, ice, water, condensation, heat, cold, ultra-violet radiation and lightning strikes
- Flexible jackets of RG-213 and LMR-400 flexible coaxial cables are easily damaged during feedline installation, antenna installation, tower maintenance, wind, ice and lightning strikes
  - Never use 9913 or similar “water hose”
  - Never use air or foam dielectric flexible coaxial cable outdoors
    - except Davis RF Bury-Flex
- Heliax and jacketed CATV hardline are highly resistant to environmental damage and provide 25 years of service
  - If no installation errors are made
  - if you perform annual inspections

UHF Coaxial Cable Connectors

- N and UHF connectors are the most commonly used
  - both have insignificant loss at HF
- High quality silver plated UHF connectors provide much more center pin mating force than any N connector
  - eliminates cross-station interference and N connector failures from:
    - unreliable center pin mating force and common pin alignment failures
    - installation errors (e.g., incorrect pin depth, misalignment and pullback)
- Avoid using adapters as much as possible
  - but if necessary use only name-brand silver plated adapters, not nickel plated
  - never use cheap import “no name” adapters and connectors
- Wrench tighten your all of your UHF connectors (1/4 turn)

Avoid saving a few dollars on cheap unbranded connectors and adapters

Amphenol 83-1SP
PL-259 Connector

Shell is labeled exactly:
Amphenol 83-1SP

Silver Plated
Center Pin

Silver Plated
Body

www.dxengineering.com/parts/aml-83-1sp

This is not a good place to save money

Coaxial Cables

83-1SP Connector Installation

www.k3lr.com/engineering/pl259

An unconventional but superb method

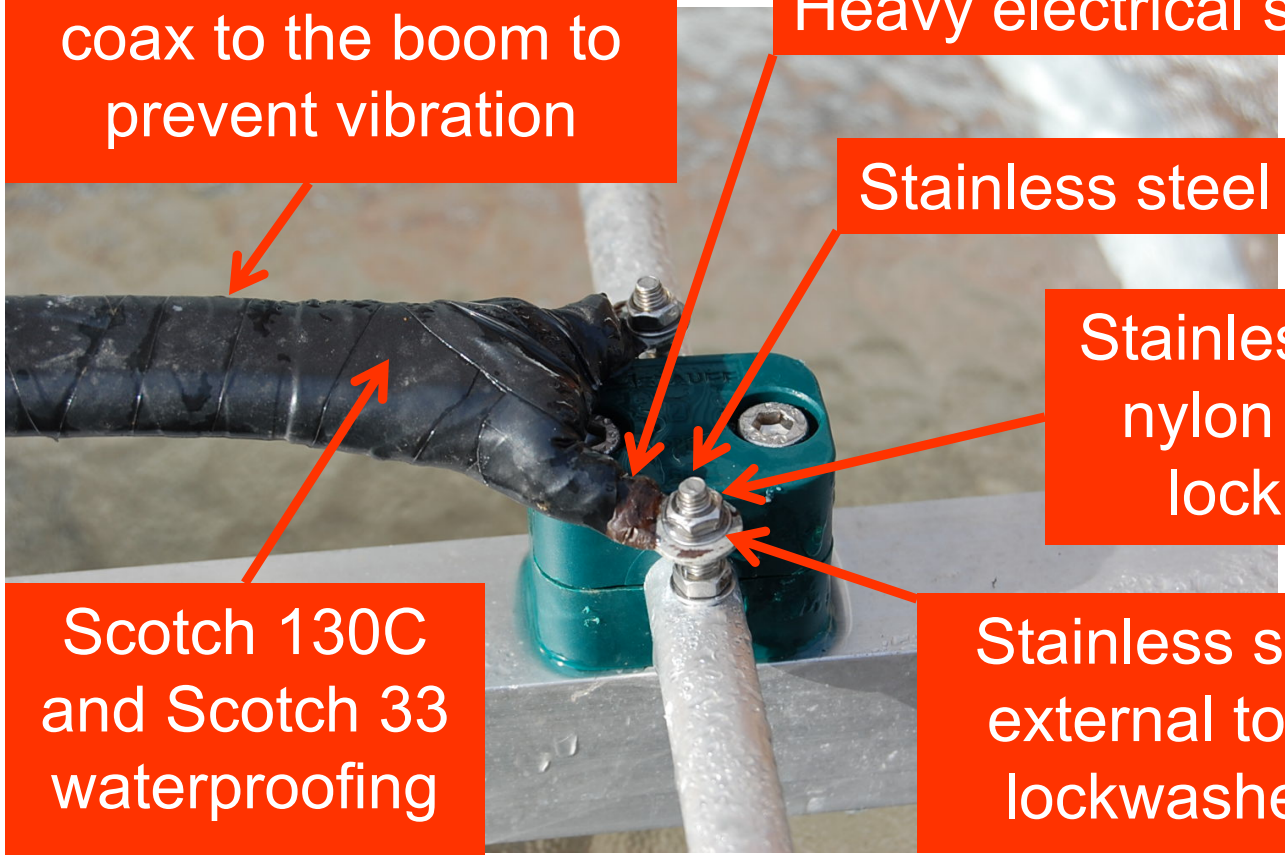
Connector Waterproofing

Cover your connectors with two 50% overlapped layers of Scotch 130C stretched to 50% of its original width, **sticky side facing out**

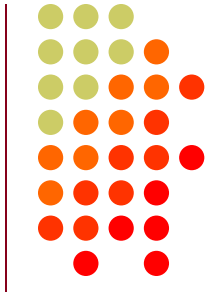
Cover the Scotch 130C with two 50% overlapped layers of Scotch 33+ or Scotch 88

Antenna Feedpoint

Waterproof and Shakeproof Connections



Coaxial Cables Can Make or Break Your Competitive Performance



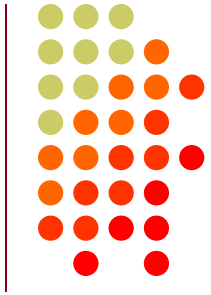
- How well you select, install, waterproof, inspect and maintain your coaxial feed lines and connectors can make or break the competitive performance of your contest station

- Cross-station interference in multi-operator and SO2R stations is often caused by
  - inappropriate or failing outdoor coaxial cables
  - inappropriate connectors (never use N connectors)
  - cheap low quality imported connectors and adapters
  - improper installation practices
  - failure to perform annual inspections and regular maintenance

Low Loss Coaxial Cables for Single Operator Stations

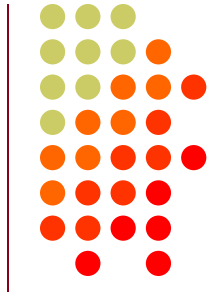
- Coaxial cable loss, proper installation and annual inspections are the most important concerns for single operator stations
  - Andrew LDF4-50A 50 ohm Heliax and connectors are commonly available at hamfests and eBay for ~ $1.00/foot
    - Less than 1 dB of loss on 10 meters for lengths up to 300 feet
  - If you must use flexible coaxial cable on your tower, Davis RF Bury-Flex is an acceptable alternative for single operator stations only, at about the same price.
    - Never use any other type of foam dielectric flexible coaxial cable
  - Non-flooded coax such as RG-213 and LMR-400 has short service life in the harsh environment on a tower
    - especially the rotating cable loop above a rotator
    - Never direct bury RG-213 or LMR-400 or lay it on wet ground

Low Loss Coaxial Cables for Multi-Op and SO2R Stations



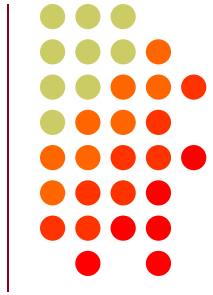
- Andrew LDF4-50A Heliax is an ideal choice for lengths up to:
  - 300 feet on 10 meters
  - 400 feet on 20 meters
  - 600 feet on 40 meters
- Eliminate common cross-station RFI sources:
  - Use Heliax to avoid RFI caused by corrosion of dissimilar metals in aluminum foil and tinned braid shields of Davis RF Bury-Flex cable
  - Signal coupling between RG-213 single braid shielded coaxial feed lines when they are bundled or run together in conduits
  - Never use nickel plated or cheap no-name connectors and adapters
  - Minimize the use of connectors and adapters as much as possible
    - Use only brand name silver plated connectors and adapters

Low Loss Coaxial Cables for Multi-tower Stations



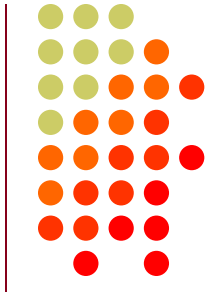
- Multi-tower stations often use coax cables longer than 300 ft
- Andrew LDF5-50A Heliax is an ideal choice for lengths up to
  - 500 feet on 10 meters
  - 600 feet on 15 meters
  - 750 feet on 20 meters
  - 1000 feet on 40 meters
- Be cautious of the windload and weight (including ice load) of large Heliax cables mounted on light duty towers such as Rohn 25 and 45

Coaxial Cable Installation on your Tower



- Wind, ice, water, condensation, heat, cold, ultra-violet radiation and lightning strikes are important concerns
  - If any of these conditions are unusually severe in your environment, implement additional protective measures
- Heliax and CATV hardline must be firmly fastened to the tower at least every to five feet to protect them from wind and ice damage
- Flexible coaxial cables (e.g. RG-213) should be firmly attached to the tower at least every two or three feet to protect them from wind and ice damage
- Use electrical tape to protect plastic tie-wraps from ultra-violet radiation

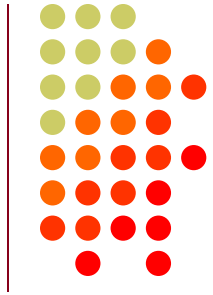
Coaxial Cable Interface to the Top of your Tower



- Coaxial cables must be bonded (“grounded”) to the top of your tower to prevent the coaxial cable jacket from developing pinholes caused by cable-to-tower arcing during lightning strikes

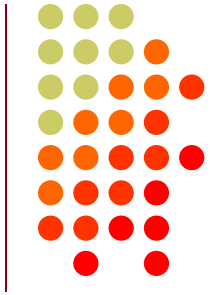
- Connectors must be carefully placed and waterproofed so that water cannot not flow down the outside of the coaxial cables then into your connectors

Coaxial Cable Interface to the Bottom of your Tower



- Tower mounted coaxial cables must be bonded ("grounded") to your tower base to prevent the coaxial cable jacket from developing pinholes caused by cable-to-tower arcing during lightning strikes
- An effective ground system must be connected to your tower base to strip lightning currents from your cables before they flow down the cable shields into your station
  - A *minimum* of three 8-foot galvanized ground rods
  - spaced at eight feet from each other and from the tower base
- Connectors must be carefully placed and waterproofed so that water cannot not flow down the outside of the coaxial cables then into your connectors

Buried Coaxial Cables



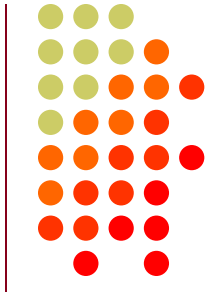
- Direct Burial
  - Use only coaxial cable that is rated for direct burial
    - Andrew Heliax, jacketed CATV cable or Davis RF Bury-Flex
  - PVC jacketed coaxial cable should never be direct buried

- PVC conduit
  - Use oversized conduit with plenty of room for pulling cables
  - Use sweeps, not sharp right angle PVC connectors
  - Use appropriate methods to drain moisture from the conduit
  - Prevent water and vermin entry into conduit entrances
  - Use only Heliax cables in multi-op or SO2R stations
    - bundled single shielded coax can cause cross-station RFI

Antenna Rotation Coax

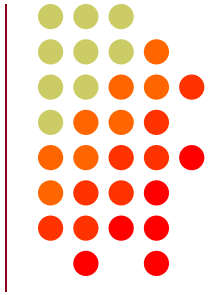
- Your antenna rotation coaxial cable is exposed to the most extreme environmental conditions in your station
- Carefully avoid allowing the coax to rub or pull against the tower or any other objects that could damage it
  - Rotators with more than 360 degrees of rotation make this extremely difficult to achieve
- Name brand, high quality, new RG-213 is an excellent choice
  - 95% shield, stranded center conductor, solid dielectric, black UV-resistant jacket
- Replace the coaxial cable whenever you discover abrasion, damage or degradation during annual inspections
- Replace at least once every ten years

Single Point Ground at the Cable Entry into your Station



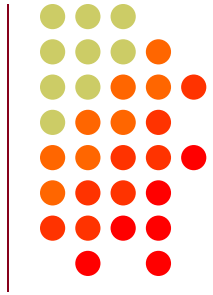
- Your station cable entry interface should establish a single point ground as close as possible to the outside wall of your building
  - Install a minimum of three 8-foot ground rods
  - spaced at least eight feet from each other in undisturbed soil
- Your single point ground strips lightning currents off of the coaxial cable shields before they enter your station
- Lightning protectors should be installed at the station single point ground
  - never install lightning protectors at your tower base

Coaxial Cables Inside your Station



- RG-213 is much more practical than Heliax cable
  - RG-223 and RG-400 are excellent choices for small diameter coax
- Eliminating cable, connector and adapter related cross-station interference in SO2R and multi-operator stations
  - Never bundle single shielded coaxial cables
    - avoids cross-cable signal coupling in single shield coaxial cables
    - use double shielded coax if you must bundle your coaxial cables
  - Use UHF connectors and never N connectors for much better center pin contact pressure and reliability
    - Use only high quality Amphenol 83-1SP silver plated connectors
  - To minimize signal radiation, use K3LR'a PL-259 installation technique and avoid nickel plated adapters

Annual Coaxial Cable Inspections



- Inspect all indoor and outdoor coaxial cables, connectors and waterproofing for evidence of damage, cuts, cracks, moisture intrusion and improper installation
  - Antenna feed point connection (wear and water intrusion)
  - Antenna rotation coaxial cable (chaffing and wear)
  - Tower top connectors and bonding to tower
  - Tower base connectors and bonding to tower
  - All coaxial cable connectors and adapters in your station
  - All SO-239 chassis connectors on your station equipment
- If in doubt, remove the connector for detailed inspection
- Verify that all indoor and outdoor connectors are wrench tight
  - ¼ turn

Coaxial Cable Measurements Inside Your Shack

- Make a record of the following measurements at the ham shack end of every coaxial cable:
  - VSWR across the entire band(s)
  - Center conductor to shield resistance
    - typically either a fraction of one ohm or many megohms
  - TDR and/or VNA plots
    - serious station builders should own (and use!) a TDR and a VNA
- Well before your next competitive contest, verify that all measurements have not changed and are not erratic
  - any change (better or worse) requires detailed investigation
- Use a digital wattmeter in your station to allow you to quickly detect and diagnose abnormal operation