Receive Four Square System

DXE-RFS-SYS-2P

U.S. Patent No. 7,423,588
DXE-RFS-SYS-2P-INS Revision 2a

© DX Engineering 2017
1200 Southeast Ave. - Tallmadge, OH 44278 USA
Phone: (800) 777-0703 ∙ Tech Support and International: (330) 572-3200
Fax: (330) 572-3279 ∙ E-mail: DXEngineering@DXEngineering.com
Introduction

The **DXE-RFS-SYS-2P Receive Four Square Electronics Package** is for the advanced AM broadcast, short wave listener or amateur radio operator who wants to build a passive receive antenna system of their own design using the highly sophisticated DX Engineering receive four square control system.

The **DXE-RFS-SYS-2P Receive Four Square Package** is a packaged system which includes:
- DXE-RFS-3 Receive Four Square Array Controller
- DXE-EC4 BCD Control Console

The **DXE-RFS-SYS-2P** allows the system designer unprecedented freedom to build a complete custom receiving system.

This patented (*US Patent Number 7,423,588*) system array configuration embodies unique phase and time shifted combining for stable broadband performance.

The **DXE-RFS-SYS-2P** is a sophisticated receiving system that is designed to be used with four identical vertical symmetrically spaced elements to provide switching for a 4-direction receiving antenna system. The system uses time delay phasing rather than the conventional narrow-band, frequency dependent phasing systems. The time delay phasing is directivity-optimized to produce wider and deeper rear nulls and a narrower main lobe. The result is that noise and undesirable signals are greatly reduced for a superior front-to-rear ratio (F/R). Better control of phase and currents provides a cleaner pattern than found on available transmit four square arrays.

This system offers greater reliability in receiving applications. The **DXE-RFS-SYS-2P** uses sealed relays sized for receiving applications with silver contacts to prevent oxidation and contamination. Most transmitting four square switches use large open-frame relays where the contacts are exposed to air which can lead to contamination. Relays with brass contacts can oxidize leading to poor conductivity.

Advantages of the **DXE-RFS-SYS-2P** Receive Four Square Antenna System over other small or medium-size receiving arrays include:
- Reduced susceptibility to high angle signals compared to EWE, Flag, Pennant, and K9AY antennas
- Excellent directivity in a small space for better signal-to-noise ratio
- Switchable in four 90 degree spaced directions
- Directivity over a very wide frequency range when using DX Engineering active elements
- Less physical space required than a Beverage antenna
- Needs only a minimal ground system
- Enhanced relay contact reliability
- Low current DC powered control console allows system operation without AC power mains

---

**Failure to make quality feedline or delay line connections might result in an array that does not work or performs poorly.**
For a turnkey package including the active antennas, 1000 ft of F6 direct burial flooded cable, connectors, tools and the DXE-TVSU-1B Time Variable Sequencer Unit, see the DXE-RFS-SYS-4P Complete System Package.

**Additional Parts Required, Not Supplied with the DXE-RFS-SYS-2P**

Four identical vertical antenna elements. This may consist of four passive vertical antennas (23-24 feet tall with an accompanying radial system, or four 102” vertical whip elements such as the DXE-WP-102.

**Four-Conductor Power and Control Cable for RFS-3**
Four conductor cable (3 plus ground), 22 gauge minimum. Economically priced COM-CW-4 is a 4 conductor Shielded Control Wire which may be used.

**DXE-CAVS-1P or DXE-SSVC-2P Mounting Clamp for RFS-3**
Pre-drilled mounting bracket accepts pipe OD sizes from 1/2 inch to 2 inches. Note: JTL-12555 Jet-Lube SS-30 Never-Seez must be used on all clamps, bolts and stainless steel threaded hardware to prevent galling and to ensure proper tightening.

**75 Ω Coax Cable (CATV F6 Style), Connectors and Installation Tools**
When calculating cable length, include connections from the phasing unit to each active element, delay lines and the distance to the operating position. You must use 75 Ω coax with a known velocity factor (VF) for all connections.

We recommend using a high quality, 75 Ω “flooded” F6 type coax, such as DX Engineering part number DXE-F6-1000. Flooded-style cables automatically seal small accidental cuts or lacerations in the cable jacket. Flooded cables also prevent shield contamination and can be direct-buried.

Feedline connections must have good integrity and be weather resistant. We recommend Snap-N-Seal type F connectors. The complete DXE-RFS-SYS-2P system, including feedline connections, requires 16 type F connectors. DXE-SNS6-25 contains 25 Snap-N-Seal connectors, enough for the entire array plus nine spare connectors.

*Note:* The DXE-CPT-659 stripping tool prepares F6 style cable for connectors in one easy and clean operation and comes with an extra cutting cartridge.

Snap-N-Seal connectors cannot be installed with normal cramping tools or pliers. The DXE-SNS-CT1 is an essential tool for proper connector installation.

*Note:* **DO NOT** use pliers or other tools to tighten the type F connectors; they do not require high torque to make a good connection. Damage to the various units may result and is not covered under warranty. Use a tool such as the DXE-CIT-1 F Connector Tightening Tool
Example of Array Performance

Dedicated receive antennas have better signal-to-noise ratios. Directing the antenna away from noise sources or toward the desired signal path is the primary benefit. Antenna gain is a secondary advantage. As frequency increases, the fixed array size becomes electrically larger in terms of wavelength. The increased electrical spacing produces higher sensitivity (average gain) even though front-to-rear ratio only changes slightly. On the low bands, once the receiving system limits on external noise, antenna directivity (F/R) is the only thing that affects the signal-to-noise ratio.

An average Beverage antenna exhibits about -6 dB gain. You would need two reversible Beverage systems to obtain 4-direction selectivity and you still would be limited to one or two bands. The DXE-RFS-SYS-2P system occupies less space, is much easier to install, is less conspicuous and operates over a wider frequency range with similar or better performance.

Note: The DXE-RFS-SYS-2P Receiving system must be separated from transmitting or other antennas and structures (particularly metal) by at least 1/2 wavelength. Less separation may cause significant pattern distortion and the introduction of re-radiated noise into the system. This becomes apparent as reduced front-to-rear directivity in one or more directions or a higher noise level.

Site Selection

Site selection is important. The DXE-RFS-SYS-2P system can be positioned as close as 1/10 wavelength to transmitting antennas.

Significant pattern distortion or coupling may result from close spacing. To prevent pattern degradation or reception of re-radiated electrical noise or other interference, separation of 1/2 wavelength (at the lowest operating frequency) is ideal. See Figure 1. The goal is to do the best you can by balancing all the factors.

Figure 1 - Site Selection Clear Distance

The minimum distance to any transmitting antenna from the Four Square perimeter is 1/10 wavelength. Greater than 1/2 wavelength distance will prevent coupling to other antennas and introduction of noise into the receive system.

Proximity to Transmitting Antennas

If the ARAV3 active elements are used on this system, your transmitting antenna and the receive four square array need only minimal physical separation to maintain safe power levels when the DXE-TVSU-1B sequencer is used. The DXE-TVSU-1B removes power from the active verticals when the transmitter is in operation. The DXE-ARAV3 Active Elements are bypassed to ground when power is turned off. Using an optional programmable sequencer, such as the DXE-TVSU-1B, is required for close spacing requirements. The DXE-TVSU-1B is included in the DXE-RFS-SYS-4P complete Receive Four Square Array Package.
With 1500 watts output and a unity gain (0 dB) antenna, the closest active element can be 1/10 wavelength from the transmitting antenna at the lowest transmitting frequency. Doubling the protection distance quadruples safe power levels. See Table 1.

<table>
<thead>
<tr>
<th>Band</th>
<th>Unity (0 dB) Gain</th>
<th>3 dB Gain (2x)</th>
<th>6 dB Gain (4x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>160m (1.8 MHz)</td>
<td>55 ft</td>
<td>110 ft</td>
<td>220 ft</td>
</tr>
<tr>
<td>80m (3.5 MHz)</td>
<td>28 ft</td>
<td>56 ft</td>
<td>112 ft</td>
</tr>
<tr>
<td>40m (7.0 MHz)</td>
<td>15 ft</td>
<td>30 ft</td>
<td>60 ft</td>
</tr>
</tbody>
</table>

Table 1 - Array Safety Distance Minimums at 1500 watts

Table 1 indicates minimum safe distances from transmitting antennas with 0 dB, 3 dB and 6 dB gain (ERP) using a 1500 watt transmitter. Your actual system may vary according to location and proximity to various objects.

For example, transmitting legal-limit power output (1500 watts) into an ideal four square transmitting array produces about 6,000 watts ERP (6 dB gain). Because of the increased radiated power level, nearly 1/2 wavelength minimum spacing between the transmitting and receiving antenna arrays is required, even when using the DXE-TVSU-1B sequencer to remove power going to the active antennas used in a receive four square. High power levels transmitted into a passive array system can also cause damage to system components.

**Topographical Considerations**

Flat land is best. Erecting the receiving array on sloped land or steep hills may degrade performance. To avoid pattern degradation, antenna elements must have reasonably similar elevations. It's recommended the ground height difference between any element in the array be less than 10% of the array diameter. For example, a 70 foot diameter array should be within six feet of level. Every effort should be taken to make the elements symmetrical. Elements should all be identical in construction and grounding, and should be mounted above any standing water or snow line but as close to the ground as possible. In general, the system will not be affected by trees or foliage as long as the foliage does not contact the element. Ideally, in important receiving directions, there should be a clear electrical path for at least 1 wavelength. The site should allow a ground system to be evenly distributed around the antenna, if one is required.

**Site Selection in Relation to Noise Sources**

Because the array is directional across its corners, use this example as a guide: If you have a noise source and if your primary listening area is northeast, locate the array northeast of the dominant noise source. This ensures the array is looking away from the source of noise when beaming in the primary listening direction. The second-best location for the array is when the noise source is as far as possible from either side of the array. If you look at patterns, the ideal location for the array is one that places undesired noise in a deep null area.

If your location doesn’t have the usual noise sources (power lines, electric fences, etc.), locate the array so that your transmitting antennas and buildings are off the back or side of the receiving array.
Noise that limits the ability to hear a weak signal on the lower bands is generally a mixture of local ground wave and ionosphere propagated noise sources. Some installations suffer from a dominant noise source located close to the antennas. Noise level differences between urban and rural locations can be more than 30 dB during the daytime on 160 meters. Nighttime can bring a dramatic increase in the overall noise level as noise propagates via the ionosphere from multiple distant sources. Since the noise is external to the antenna, directivity can reduce noise intensity.

Consider these things about noise sources:

- If noise is not evenly distributed, performance will depend on the gain difference between the desired signal direction (azimuth and elevation) and average gain in the direction of noise.
- If noise predominantly arrives from the direction and angle of desired signals (assuming polarization of signals and noise are the same) there will be no improvement in the signal-to-noise ratio.

If the noise originates in the near-field of the antenna, everything becomes unpredictable. This is a good case for placing receiving antennas as far from noise sources (such as power lines) as possible.

**Ground System**

For a customer supplied passive vertical system, ground radial requirements will vary and some experimentation may be required to achieve optimum results.

The **DXE-ARAV3-1P** Receive Antenna Active Vertical w/Relay works well with just a single copper ground rod placed as close as possible to the mounting pipe. The mounting pipe can be used as the system ground if the pipe is an adequate ground. It is recommended that a 3/4" or larger rigid copper water pipe, although conventional copper coated steel rods may also work. Depending on soil conductivity, you can expect better performance with multiple ground rods spaced a few feet apart. Increasing ground rod depth beyond 5 ft rarely improves RF grounding because skin effect in the soil prevents current from flowing deep in the soil. Avoid ground rods less than 5/8" OD. A good ground system improves the array performance and enhances lightning survivability. It is important that each ground system be the same for each active antenna in the array. Some passive antenna systems may require a larger radial system for performance.

You can test ground quality by listening to a steady local signal. Attach 15 ft of wire laid in a straight line (away from the coaxial feedline) to the initial 4 ft to 6 ft ground rod. If you observe a change in signal or noise level, you need to improve the ground. A second rod spaced a few feet away from the first one may correct the problem or 10 to 12 ground radials, each 15 ft long, should provide a sufficient ground system for most soil conditions. If a good ground cannot be established, use an optional **DXE-RFCC-1** Receive Feedline Current Choke that will further decouple the feedline from the antenna and reduce common mode current and associated noise from the feedline.
Lightning Protection

While amateur radio installations rarely suffer damage from lightning, the best protection is to disconnect electrical devices during storms. The key to lightning survival is to properly ground feedlines and equipment and to maintain the integrity of shield connections. A proper installation improves lightning protection and enhances weak signal receiving performance.

Consult lightning protection and station grounding information in the ARRL handbooks, or by referring to the NEC (National Electric Code). The DX Engineering website also has technical and product information listed under “Lightning Protection and Grounding.” Use lightning surge protectors for the coax feedline and control lines.

Four Square Layout

The receive four square array antenna elements should be arranged in a square with the side lengths equal to 1/4-wavelength of the target frequency for optimal results. The diagonal corners of the square should point in the most desirable receiving directions. Element 1 is the default forward element, Element 3 is the rear or null element. Position 1 in the EC-4 Controller would switch the four square array to the North East toward Europe (preferred direction for use in North America).

- Performance of the RFS-3 can noticeably decrease if structures radiating even small amounts of noise or signals are within 1-wavelength of the array
- Measure side-to-side and then corner-to-corner to ensure the element locations are square.
- Normally the RFS-3 phasing unit is installed near the center of the four square array elements, above any standing water or snow line, with the connector side facing down. The
placement of the RFS-3 unit is not critical, however, the feedlines to each of the active elements must be equal.

- If you mount the RFS-3 on a wood post, it should be grounded to a separate ground rod.

**System Operational Overview**

The DXE-RFS-SYS-2P system is comprised of the DXE-EC-4 BCD Control Console and the DXE-RFS-3 Control Unit. These units interconnect and work together.

The DXE-EC-4 BCD Control Console supplies the nominal +12 Vdc operational voltage as well as the +12 Vdc BCD control voltage. The operational voltage powers the DXE-RFS-3 Control Unit which subsequently powers the active receive elements. The BCD switching voltages cause the DXE-RFS-3 to change the receiving direction of the array. The DXE-EC-4 needs a +12 Vdc, 1A, fused power input which may be supplied by your well filtered and fused power supply.

If you are using active elements, the DXE-RFS-3 distributes the operating power to the active elements through the individual element feedlines. The active elements do not work without power. Cutting power to the DXE-RFS-3 also cuts power to the active elements which causes the AVA2 to ground the vertical element.

**Installation**

The DXE-RFS-3 Control Unit can be mounted to a galvanized pipe driven into the ground. The DXE-RFS-3 unit has been pre-drilled to accommodate up to a 2 inch OD pipe using the included DXE-SSVC-2P Stainless Steel V-Bolt Saddle Clamp for 1" to 2" OD pipe. If smaller pipe mounting is desired, the optional DXE-CAVS-1P V-Bolt Saddle clamp for pipe from 3/4" to 1-3/4" inches OD is recommended. The controller can also be mounted on a sturdy wooden post, but provision for grounding the DXE-RFS-3 unit must be made.

The DXE-RFS-3 is designed to be used with the DX Engineering Active Vertical Antennas or, it can be used with passive elements. The active elements should be installed as close to the ground as possible but above any standing water line. **Ground the ANT– (negative) terminal to an adequate ground.**

**Active Antenna Elements - If Used**

If you are planning to use the array on 160m, a jumper in the active antenna matching units should be changed. Placing a jumper on L1MF will peak the array sensitivity response for use on 160m, with little effect on 80m. When doing this the sensitivity for the AM broadcast band will be reduced. All four active elements in the array must have identical jumper settings.
For access to the jumpers in the active matching units, remove cover. The circuit board and jumper headers will be visible, as shown in Figure 3. By default, there are no jumpers across any pins. Place a jumper across L1MF. Do not jumper any other positions. See the Active Antenna User Manual for more information about additional peak response jumper settings.

**Station Feedline, Active Antenna Feedline and Delay Lines**

The weakest link in an antenna system, such as the DXE-RFS-SYS-2P, is often the coax cable connections. All connections must be high quality and weather tight to prevent contamination and corrosion, which can cause the feedline impedance to change. This can affect the signal-to-noise ratio and the directivity of the array. In addition, the DXE-RFS-3 uses the shield as a ground return path for the active element power.

*Note: The total loop resistance of the ground path must be under 30 Ω for reliable operation.*

If the resistance of the shield increases due to contamination, the elements may not function properly. Any splices in the feedline should be high quality and entirely weather tight. The DXE-RFS-3P system has been designed to use only 75 Ω coax.

High quality, flooded 75 Ω CATV F6 type coax is recommended. DXE-F6-1000 Flooded cables automatically seal small accidental cuts or lacerations in the jacket. Flooded cable also prevents shield contamination and can be direct-buried.

DX Engineering offers an inexpensive preparation tool, part number DXE-CPT-659, that readies the coax for connectors in one operation and comes with an extra cutting cartridge. To ensure weather tight connections, use DXE-SNS6-25 Snap-N-Seal compression style connectors. DXE-SNS6-25 contains 25 Snap-N-Seal connectors, enough for the entire array plus some spares. The Snap-N-Seal connectors cannot be installed with normal crimping tools or pliers, so you must use an installation tool like the DXE-SNS-CT1, available from DX Engineering, for proper connector installation.

**Delay Lines**

The DXE-RFS-3 uses a time delay system, not a traditional phasing system. Delay line lengths are dictated by array dimensions rather than operating frequency. This results in phase being correct for a rearward null at any frequency. This system is especially effective when used with DX Engineering ARAV active elements. User-supplied passive elements can also provide exceptional performance for single or dual band operation where high dynamic range is required.

The DXE-RFS-3 phasing unit has three sets of delay line connections marked DLY1, DLY2 and DLY3. Each of these connection pairs will have a specific length of coax acting as a jumper between the two connectors. Jumper electrical length is critical. Careful measurements and the use of 75 Ω coax with a known Velocity Factor (VF) is very important.

Solid Teflon® or polyethylene dielectric coax cable has a VF of approximately 0.66. Foamed coax cables typically range anywhere between 0.75 and 0.90 VF, depending on the ratio of air-to-dielectric material in the cable core.
If you do not know the VF of the coax you are using, you must directly measure the electrical length of the coax you have or obtain cable with a known VF. The DX Engineering DXE-F6-1000 75 Ω coax has a nominal VF of 0.85. For best performance, the coax for the delay lines should be from the same batch or spool.

The first step is to determine the required electrical length of DLY3. This is based on the corner-to-corner or diagonal distance between two diagonal corner elements of the square forming the array. You can directly measure this distance, or it can be calculated by multiplying the side length of the array by 1.4142. The electrical length of delay line DLY3 should be slightly shorter than the actual physical distance between the two diagonal corners of the array. An electrical length 95% of the physical distance works well (diagonal distance times 0.95). Table 2 shows these calculations for three common side lengths.

<table>
<thead>
<tr>
<th>Side Length in Feet</th>
<th>Diagonal Physical Length in Feet</th>
<th>Factored 0.95 Electrical Length in Feet</th>
<th>DLY3 Physical Length in Feet (0.85 VF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>270 (900 kHz)</td>
<td>382</td>
<td>363</td>
<td>308.4</td>
</tr>
<tr>
<td>135 (160m - 1.8 MHz)</td>
<td>190.9</td>
<td>181.4</td>
<td>154.2</td>
</tr>
<tr>
<td>98 (160m &amp; 80m)</td>
<td>138.6</td>
<td>131.7</td>
<td>111.9</td>
</tr>
<tr>
<td>70 (80m - 3.6 MHz)</td>
<td>99.0</td>
<td>94.0</td>
<td>79.9</td>
</tr>
<tr>
<td>35 (40m - 7.2 MHz)</td>
<td>49.5</td>
<td>47</td>
<td>40</td>
</tr>
</tbody>
</table>

Table 2 - Examples of DLY3 Required Length

After calculating the required electrical length, you must include the VF of the coax being used when determining the correct physical length of DLY3. Multiply the factored electrical length by the VF. The result is the correct physical length for DLY3. See Figure 4 and the sidebar for an example. **Note:** These calculations are in feet, not feet and inches.

To find the physical length of DLY3, calculate the diagonal length of the array by either directly measuring the diagonal or by multiplying the array side length by 1.4142. DLY3 will be significantly shorter than the actual physical length. The diagonal length is first multiplied by 0.95. This gives the factored electrical length for DLY3. Next, multiply the DLY3 electrical length by the VF of the delay line coax. The result is the correct physical length for DLY3.

**Figure 4 - Diagonal Dimension**

**For Example:** An array with 90 foot side spacing, the diagonal length is 127.3 feet. The 0.95 factored physical length for DLY3 electrical length is 120.9 ft. Multiply 120.9 ft. by 0.85 (the VF of DX Engineering 75 Ω coax).

The correct physical length for DLY3 is 102.77 feet, or 102 feet 9 inches.
Delay lines DLY1 and DLY2 must be half the length of DLY3. Make DLY1 and DLY2 as close to half the physical length of DLY3 as possible. To avoid performance degradation due to inconsistent coax construction, all the delay line coax should be cut from the same spool.

Delay line cables can be neatly coiled in a 1-1/2 ft diameter coil. Support the weight of the cables by taping or securing them to the support pole or mast rather than allowing them to hang from the connectors. It is important to use 75 Ω feedline to the operating position from the DXE-RFS-3. Do not use amplifiers, combiners, filters or splitters that are not optimized for 75 Ω systems.

Active Antenna Feedlines

Use 75 Ω coax from each antenna element to the DXE-RFS-3. The four feedlines from the DXE-RFS-3 phasing unit to the active elements can be any length needed to accommodate the size of the array, but must all be the same length, velocity factor and type. Note the orientation and numbering of the elements by using Figure 2. Be sure the appropriate antenna element is connected to the proper ANT connector on the phasing unit. The default (zero control voltage) forward direction is towards Element 1. Element 3 is the rear or null direction.

Control and Power Connections

The DXE-RFS-SYS-2P system, with the DXE-EC-4 BCD Control Console, no other equipment is needed for powering the DXE-RFS-3, the active elements or controlling the receive direction.

J12 is the 5-terminal connector plug on the front panel of the DXE-RFS-3. It is labeled G A B C G.

The DXE-RFS-3 uses a two part green connector and the top part can be removed by pulling it straight off. This will allow easier wire replacement or servicing as needed. When pushing the connector back in place, ensure you press straight inward.

The DXE-EC4 uses an internal terminal plug labeled “G 1 2 3”.

<table>
<thead>
<tr>
<th>DXE-EC-4</th>
<th>DXE-RFS-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
</tr>
<tr>
<td>3 *</td>
<td>C *</td>
</tr>
</tbody>
</table>

* Wire connections between the DXE-EC-4 and DXE-RFS-3

* In a passive array system, the wire from EC-4 connection 3 to RFS-3 Connection C is not required.
The switch positions on the **DXE-EC-4** control the directivity of the received signal in the **DXE-RFS-SYS-2P**.

As shown in the diagram to the right, position one favors the NE direction, position 2 favors the SE direction, position 3 favors the SW direction and position 4 favors the NW direction when the array is positioned as shown.

Control lines (usually BCD) can normally use good quality CAT5e cable (4 twisted pairs of 24 AWG wire) for runs up to 1000 feet. Typical DX Engineering BCD control lines requirements are +12 VDC at 25 milliamps. Depending on the number of control lines needed (usually 3 or 4) you can double up the twisted pairs of CAT5e cable, or use control wire that is at least 22 AWG, allowing runs up to 1500 feet. If you use a cable with more conductors, it is a good idea to tie the unused conductors to ground. For longer runs of control cable, use a line loss calculator to ensure you supply the proper control levels needed.

**Approximate BCD Control Line Lengths.**

<table>
<thead>
<tr>
<th>Minimum Copper Wire Gage (AWG)</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>1,000 feet</td>
</tr>
<tr>
<td>22</td>
<td>1,500 feet</td>
</tr>
<tr>
<td>20</td>
<td>2,000 feet</td>
</tr>
</tbody>
</table>

Active antenna circuitry needs a good voltage supply to operate properly. When supplying power to an active antenna, you want to have +12 VDC, 60 milliamps at each active (under load). CAT5e cable is not recommended when making long runs to power an active antenna since the line loss in CAT5e cable may not supply the proper operational voltages required for active antennas.

Depending on the required length of your power wire, you will want to use a line loss calculator (voltage drop with various wire gages) to ensure your power supply (normally +13.6 well filtered DC) will supply a minimum of +12 VDC, 60 milliamps at each active antenna (under load). A DX Engineering 4 Square or 8 Circle will require approximately 250 milliamps (only 4 actives are powered at any one time).

When calculating line length, take into consideration the total number of active antennas being powered at any one time in your line length calculations.
Approximate Active Antenna Power Line Lengths (4 active antennas on at any one time).

<table>
<thead>
<tr>
<th>Minimum Copper Wire Gage (AWG)</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>300 Feet</td>
</tr>
<tr>
<td>16</td>
<td>500 feet</td>
</tr>
<tr>
<td>12</td>
<td>1,200 feet</td>
</tr>
<tr>
<td>10</td>
<td>2,000 feet</td>
</tr>
</tbody>
</table>

**DXE-RFS-SYS-2P Connection Diagram**

Shown with optional DXE-RFCC-1 Feedline Current Choke, DXE-RPA-1 HF Preamplifier and DXE-ARAV3-4P Active Vertical Receive Antenna units.
Internal Jumper Selection

To access the DXE-RFS-3 jumper blocks, remove the screws holding the cover of the DXE-RFS-3 unit. The jumper blocks should be visible and oriented as shown in Figure 5.

*Important Note:* You cannot use coax for multiple functions. If you are going to use the coax for directional control, then you cannot use the coax for powering active elements. Separate cable must be used. We recommend using the default configuration as shown in the diagram on the previous page.

Default Jumper Configuration Settings

Figure 5 shows the default jumper settings for the DXE-RFS-3. For JMP1 & JMP2 the center and top pins of both are shorted. For JMP3 & JMP4, the center and bottom pins of both are shorted. This recommended configuration is required for control and power connections from the DXE-EC-4 Control Console to the DXE-RFS-3 controller as shown on the previous page.

[Diagram showing jumper locations]

Figure 5 - Jumper Locations showing Default Settings

- **JMP1** Selects Power Voltage Source: Coax or J12 - Shown in default position, voltage from J12
- **JMP2** Selects Direction Voltage Source: Coax or J12 - Shown in default position, voltage from J12
- **JMP3** and **JMP4** Select Directional Voltage Configuration, either Differential or BCD.
  - Both Jumpers must be set the same. - Shown in default position for BCD

Optimizing the Array

To determine if the antenna system output level is the limiting factor, tune the receiver to the lowest band at the quietest operating time. This is usually when propagation is poor but some signals are heard. Disconnect the antenna and set the receiver to the narrowest selectivity you expect to use. Receiver noise power is directly proportional to receiver bandwidth (going from 2.5 kHz selectivity to 250 Hz selectivity reduces noise by 10 dB). Connecting the antenna should result in a noticeable increase in noise. If so, the array signal level is sufficient and further optimization or amplification may not be needed.
If the array is used on 160m or below, the Active Antenna internal jumper should be set as shown in the Installation Section of this manual. If the array still lacks sensitivity on the lower bands, then a preamplifier with high dynamic range should be used to compensate for the low signal level. Using a preamplifier when sufficient signal is already present may result in amplification of the noise along with the signal. **It is always best to use the least gain possible.** Depending on conditions, a preamplifier can cause receiver overload; this may require an attenuator or bypassing the preamplifier.

The **DXE-RPA-1** HF Preamplifier has better dynamic range than most receivers and can be used to compensate for the decrease in array signal output. The **DXE-RPA-1** preamplifier is automatically bypassed when power is removed.

**Front-to-Rear (Null) Optimizing**

The **DXE-RFS-3** is factory adjusted to the correct settings for most coaxial cables. In rare cases, the null depth may need to be adjusted to compensate for inaccurate delay line lengths. To adjust the null depth, tune to a strong steady signal off the back of the antenna’s selected direction and adjust R4 and R8 for the deepest null (weakest signal off the back). Use **Figure 5** to locate R4 and R8 near the center of the circuit board.

**Operation**

When using the **DXE-RFS-3**, positions 1 through 4 on the **EC-4 BCD Control Box** will phase the appropriate active vertical elements to give you excellent receiving capabilities.

The front to back signal to noise ratio of the active vertical elements in the four phase array allow you to not only enhance the desired received signal, but also to decrease an unwanted receive signal by selecting a position that will drastically reduce or eliminate it.

**Normal Receive Four Square Operation**

When the Receive Four Square system is functioning properly, low or medium power **daytime** AM Broadcast ground wave signals should be alternately attenuated or improved with directional switching. However, strong sky wave signals arriving at high angles of propagation will show very little signal level change as different directions are selected on the Receive Four Square.
Although some low band signals may be received at very low levels, they are heard more easily due to far less noise received by the non-resonant array. Use the **DXE-RPA-1, Receiver Preamplifier** - an in-shack pre-amplifier with exceptionally low-noise and high dynamic range characteristics. The **DXE-RPA-1** will enhance the intelligibility of the weak DX signals, without adding the noise that plagues many of the pre-amps that are built into modern transceivers. This preamplifier is especially helpful with passive antenna arrays which have very low signal levels.

The Receive Four Square array pattern is designed to enhance forward low angle signals, and reject rearward and high angle signals. The Receive Four Square system provides superior signal-to-noise results that allow you to hear signals that are impossible to copy on much noisier transmit antennas, for greatly improved weak signal DX operations.

**Receive Four Square Troubleshooting**

Much of this information is related to active vertical antennas, but some of these steps would be required for troubleshooting a passive receive four square antenna system.

There are several possible causes for a malfunction of a DX Engineering Receive Four Square System. Testing the system is not difficult and can be completed in an hour or so. Separate circuits for directional switching, Active Vertical Antenna power, and antenna phasing can each be affected by a variety of cabling, connection and or component problems. If you are troubleshooting a new system or using a replacement **RFS-3** unit, check that the internal jumpers are set correctly for your system control and voltage configuration.

Here are the most common causes of Receive Four Square malfunction, especially in a system that was previously functioning properly:
A) Broken and/or shorted conductors due to animal, weather or other damage, including chewed, punctured, stretched and broken control and power lines and/or feedlines for the system and each antenna. Also, screws in the green removable connectors can inadvertently be tightened onto the insulation of control or power conductors.

B) Regressed center conductors in the feedlines causing disengagement from the female center capture pin of the F connector. This can happen in delay lines as well as in antenna or main feedline connections. Many times a compression F connector that seems to have a long enough center conductor when it was made, has regressed to the point that it is not long enough to make proper contact. A properly installed F connector should have the center conductor protruding 1/4 inch beyond the shell when viewed from the side. Check all F connectors!
C) Shorted or opened conductors caused by water migration into a control line or a feedline.

Over 80% of all Receive Four Square (RFS) malfunctions have been caused by the above system problems. A thorough inspection and subsequent testing of each control cable, RF cable, and their respective connections, will uncover the cause of most RFS troubles. Here are a few other causes for RFS malfunction:

D) One or more burned out Active Vertical Antenna units model AVA-2 or AVA-1, due to lightning pulse or high power RF overload. One-half wavelength on the lowest frequency is the minimum distance between the Active antennas and any transmit antennas. If that distance is less and high power is used, then the Time Variable Sequence Unit, model DXE-TVSU-1B must be used to interrupt power to the AVA-2 units.

E) Damaged RFS-3 unit due to lightning. This has been reported only a couple of times and is not very likely.

F) Active units that were damaged by animals. Once we received actives damaged by an animal that relieved themselves on the antenna whips and AVA units, as if they were “trees”.

The above items are the most common failure points in the system that need to be checked.

If necessary, the following further troubleshooting procedure may assist in finding the malfunction.

**Receive Four Square Control Troubleshooting Procedure**

1) Test the DXE-EC-4 BCD Control Console unit, which should be connected only to the control lines of the Receive Four Square System. When the EC-4 is connected to the control cable, do all of the selected switch position LEDs light normally?

2) When rotating the Control Console switch from position 1, 2, 3 and 4, if all LEDs light normally, measure BCD output voltages. Normally, +12 for the EC-4 is output on the green connector terminals located inside the unit. Connections 1, 2 and 3, reference to the ground pin G as shown below. The selected position will supply the BCD logic voltage as shown in the chart below.

<table>
<thead>
<tr>
<th>Forward Direction</th>
<th>EC-4 Switch Position</th>
<th>BCD Terminal 1</th>
<th>BCD Terminal 2</th>
<th>BCD Terminal 3</th>
<th>EC-4 LED Illuminated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element 1 (Default)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td># 1</td>
</tr>
<tr>
<td>Element 2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td># 2</td>
</tr>
<tr>
<td>Element 3</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td># 3</td>
</tr>
<tr>
<td>Element 4</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td># 4</td>
</tr>
</tbody>
</table>

**BCD Directional Control Matrix, “1” Equals +12 Vdc (Default)**

The numbered terminals of the 4-pin green connector correspond to the numbers in the table above, with voltage measured as referenced to the G ground terminal.
3) If the voltages are not normal, less than +10 to +18 Vdc, with the control line connected, then disconnect the control line and retest the Control Console. If voltages that were not correct, are now okay, that indicates a short in the control line or a problem in or beyond the RFS-3 Receive Four Square relay unit.

4) If the EC-4 has only a couple LEDs lit with the control cable disconnected, then it may have sustained lightning pulse damage and will need to be repaired or replaced. A new DXE-EC-4 is available from DX Engineering.

Continue troubleshooting the array control with a good EC-4 or by using a well filtered 1A fused power source.

5) Determine if the control line is intact by resistance or voltage testing each conductor for shorts with the far end of the control cable disconnected from the RFS-3 unit.

6) With a good EC-4 or other power source connected, measure A, B and C control conductor voltages at the RFS relay unit with the control cable connected, and again at the end of the control cable that is disconnected from the RFS relay unit. If measured voltages are not between +10 to +18 Vdc on the selected line, a resistive, short or open circuit problem exists in the control line or in the RFS relay unit or antenna feedlines. Normal voltages on the connected control line will cause relays to switch inside the RFS unit. If switching voltages are correct, lack of system directivity or gaps in reception may be due to antenna, feedline or delay line issues.

7) Test the Active Antennas by feeding a voltage on the tested control line A and/or B conductor(s) to select one direction of RFS unit operation. Simultaneously feed normal operating voltage on the tested conductor that powers the Active Verticals for reception. If a low value fuse blows, then a short circuit may be isolated by disconnecting antennas and reconnecting them one at a time.

If no fuses have blown and connected voltages stay near the nominal +12 Vdc levels, then:

8) Test for active operating voltage at the end of each antenna feedline. If all are good, proceed. If not, repair feedlines and/or connectors. If voltage is present on the power line to the RFS relay unit, but is not measured at the end of good feedlines, inspect inside RFS-3 relay unit to determine if there is an obvious reason that Active Vertical Antenna RFS-3 relay unit power is not making it out the antenna ports. A bad connection outside of the RFS relay unit is usually the problem, and rarely has a component failure inside the RFS relay unit been discovered. If the system previously functioned properly, then the internal jumpers would have been previously set in their proper positions for your system configuration. If you are troubleshooting a new system or using a replacement unit, check that the internal jumpers in the RFS-3 unit are set correctly for your system control and voltage configuration.

Proper Receive Four Square phasing requires that each Active Vertical Antenna, and its respective equal length feedline, actually provides the same signal level to the RFS unit. Use a steady, non-fading ground wave signal from a low or medium power daytime AM Broadcast station that is over 10 miles away, on a frequency high in the band, or another constant signal source on 160 or 80 meters, well away from the array, to test that each Active Vertical receives the same signal level. Do not use sky wave or night signals for these signal level tests.
9) Test reception of each Active Vertical Antenna by connecting each antenna feedline, one at a time, to an activated port on the RFS-3. This assumes that a good port has been identified and is functioning properly. Normal reception must be confirmed from each antenna. If any antenna is not providing the proper RF signal level, move the AVA unit to a known good feedline position to rule out the possibility that a bad feedline is attenuating the RF. If one or more Active Receive Verticals produce a low or no signal, then the AVA unit at the base of that antenna may not be receiving power. Retest for DC power at the antenna end of that feedline. If +10 to 18 Vdc is found, then the Active unit may need to be serviced or replaced. New DXE-AVA-2 units are available separately by calling DX Engineering.

10) If all Active Verticals tested provide the same signal level, then change switching voltages to activate the other ports, one at a time, and test each RFS unit port, using one of the good antennas, testing for the same level of reception. If one or more ports is dead or has diminished reception, there may be a problem in a delay line or in the RFS unit.

11) Using tested or replaced delay lines and connectors, if one or more ports is dead or has diminished reception, the RFS unit may require service or replacement.

At this point, the problem in your system should have been identified.

If you need additional assistance from DX Engineering, feel free to call or write. Detailed discussions of system function, connections, and troubleshooting is best handled by telephone, Monday through Friday, 8:30 am to 4:30 pm Eastern Time, at 330-572-3200.
Optional Items

DXE-WP-102 - 102 inch Stainless Steel Whip
This 102" whip antenna is made from the finest 17-7 ph tapered stainless steel which resists bending and kinking. This material is so tough it can be bent 180 degrees and will spring back to its original shape. Dissipation tip to reduce unwanted static buildup. Fits all 3/8 x 24 threaded mounts.

- Can be bent 180 degrees and will spring back to its original shape
- Resist bending and kinking
- Excellent for all off-road terrain

DXE-CAVS-1P - V-Bolt Saddle Clamp, 1/2 in. to 1-3/4 in. OD Applications
This V-Clamp is made in one size that fits tubing from 1/2 to 1-3/4" OD as used in antenna construction. The supplied V-bolt is long enough to attach tubing to thick plates and is made with anti-corrosive properties. The cast rippled surface of the saddle will clamp the tubing securely to a flat surface; however, for high-torque applications please use our standard U-Bolt Saddle Clamps.

- Used to clamp 1/2 to 1-3/4" (OD) tubing
- Designed for attachments that don't require resistance to torque
- V-bolt made from high-strength 18-8 stainless steel
- V-saddle cast from 535 aluminum with rippled surface

The use of an Anti-Seize compound is HIGHLY recommended to achieve proper torque and prevent galling.

JTL-12555 Jet-Lube™ SS-30 Pure Copper Anti-Seize
Jet-Lube™ SS-30 Pure Copper Anti-Seize is the top choice of engineers and technicians in government, industry and leading Amateur Radio contest stations, for protecting mechanical assemblies of aluminum tubing, general hardware and copper grounding systems. On bonded metal surfaces Jet-Lube™ SS-30 assures electrical and RF conductivity while preventing oxidation and corrosion. Surpassing the capabilities of other aluminum anti-oxidants, the wide temperature range of Jet-Lube™ SS-30 prevents long-term drying and caking, and allows easy disassembly and effortless cleaning of parts. An environmentally preferred thread lubricant and conductive termination compound, Jet-Lube™ SS-30 helps keep your equipment in serviceable condition. It contains a high concentration of copper flakes, a requirement for heavy loads or compression; controlled frictional characteristics allow the surfaces of nuts and bolts to be tightened to their design torque specifications. This anti-seize product assures full hydraulic efficiency by allowing the metal surfaces to slide over each other without damaging metal-to-metal contact. Jet-Lube™ SS-30 is also designed to work as a similar and dissimilar component between two metal surfaces to prevent seizing and galvanic action. The SS-30 compound formula improves conductivity and ground continuity and will not melt in high temperatures.

Jet-Lube™ SS-30 Pure Copper Anti-Seize Features include:

- Meets MIL-PRF-907E spec
- K-factor: 0.13
- Service rating: -65 degrees F (-54 degrees C) to 1800 degrees F (820 degrees C)
- SS-30 Resistivity (ohm-CM x 108) 5

DXE-F6-1000 - 75 Ω F-6 Style Direct Bury Coax, 1000 ft. Spool Hi Quality "Flooded" Coax
_Sold by the spool, or as Custom Cable Assemblies_

Center Conductor: 18 AWG Copper-Clad Steel , Nominal Diameter: 0.040 in.
Dielectric: Gas Expanded Polyethylene, Nominal Diameter Over Dielectric: 0.180 in.
Shield: 1st Shield: Aluminum-Polypropylene-Aluminum, Laminated Tape with overlap Bonded to the Dielectric, Nominal Diameter Over Tape: 0.187 in.
2nd Shield: 34 AWG Aluminum Braid Wire, 60% Coverage
Jacket: PE (Flooded for Underground), Nominal Diameter Over Jacket: 0.272 in. , Nominal Jacket Thickness: 0.030 in.
Electrical Properties: Impedance: 75.0 +/- 3.0 Ωs, Velocity of Propagation: 85.0% Nominal

We recommend the use of Snap-N-Seal connectors to ensure a high quality and weather resistant feedline connection. The proper tool must be used to install these connectors.
DXE-CPT-659 - Coax Cable Stripper for CATV F-6, RG-6 and RG-59 coax
Prepares CATV F-6, RG-6 and RG-59 coax cable for the installation of an "F" type connector.
- One-step cutting motion
- Precision cut
- No nicks or scratches to conductor
- Includes 1 replacement blade

DXE-SNS6-25 - Watertight Coax Connector, Snap-N-Seal for CATV F-6 Cable, 25 pieces
Snap-N-Seal is an environmentally sealed CATV F coax connector system for harsh environments. The connectors have a unique, 360 degree radial compression system that offers the signal leakage protection required for high performance receive systems.
- Quad sealed system prevents moisture from migrating into the connection
- 360 degree radial compression provides superior RF integrity (-95 dB typical, 60% bonded foil cable)
- Easy cable preparation
- Connector to cable retention of 40 lbs minimum
- Superb impedance match to 1 GHz
- Manufactured of high quality 360 brass, cadmium plated with yellow chromate coating for maximum corrosion resistance
- UV-resistant plastic and O-rings provide a reliable environmentally sealed connector
An installation tool, such as the DXE-SNS-CT1, is required to install the connectors. Normal crimping tools or pliers will not work.

DXE-SNS-CT1 - Compression Tool for Snap-N-Seal 75 Ω Coax Connectors
Ratchet compression tool for installing Snap-N-Seal 75 Ω Coax connectors. Ordinary pliers will not install these connectors properly.

COM-CW4 - Cable, 4 Conductor, Sold per Foot
A high quality, PVC jacketed 4-wire control cable, COM-CW4 consists of 4 #20 AWG conductors. It may be used in a multitude of control cable applications, such as remote switching and antenna rotators.

Sold by the foot - order the length you need.

DXE-ARAV3-4P - Receive Antenna Active Vertical w/Relay Pkg. of 4
The DXE-ARAV3-4P Active Receive Antenna array package contains 4 of the DXE-ARAV3-1P Active Receive Antennas. This package is intended for use with the DXE-RFS-3P Receive Four-Square system to build a Four-Square Receiving Array. The FVI-1 Feedline Voltage Injectors are not included as the RFS-3 has provision for powering the active antennas.
The ARAV3-4P Vertical Array System package Includes:
- Four Active Antenna Verticals, for use with the DX Engineering DXE-RFS-3P Receive Four Square system.

DX Engineering’s Active Receive Antenna system offers excellent receiving performance from 100 kHz to 30 MHz using a whip antenna element 102 in. long. DX Engineering’s unique design makes it vastly superior to traditional active antennas in both strong signal handling and feedline decoupling. You get significantly better weak signal reception due to lower spurious signal interference and reduced noise. This antenna system is ideal for Amateur Radio or Shortwave Listening.

The ARAV3-4P active antenna grounds the antenna element when power is turned off. This active antenna is used in installations with spacing from transmit antennas less than 1/2 wavelength but more than 1/10 wavelength (on the lowest frequency). Sites with no room for proper spacing should use the ARAV3-4P, which can be installed in close proximity to transmitting antennas (1/10-wavelength of the lowest transmitting frequency), provided the unit is powered off at least 5 ms before transmitting. A sequencer such as the DXE-TVSU-1B should be used to ensure the correct transmit to receive switching. The DXE-NCC-1 Noise/Phase Controller can provide the power for the active antenna and the proper transmit power-off sequencing.
**DXE-CIT-1 - F Connector Tightening Tool**
The CIT-1 installs and removes F connectors in high density and hard to reach locations, and is the only tool that works with bent coax. Only finger force is required. Provides enough leverage to achieve a 30 in/lb tightening force by hand. Helps insure proper connections thereby reducing the potential of loose connector related service calls.

**Time Variable Sequencer Unit - DXE-TVSU-1B**
The DX Engineering TVSU-1B Time Variable Sequencer Unit is a microprocessor-based transmit / receive control-signal delay unit. It provides 0-30 ms of delay, programmable in 2 ms increments, to as many as five outputs tied to the CW keying or push-to-talk (PTT) lines. By controlling the receive-to-transmit (and back) timing of linear amplifiers, preamplifiers, and other sensitive equipment, damage caused by improper switching can be eliminated. This sequencer improves CW performance by eliminating annoying leading edge chopping or truncating of Morse characters. This is especially important in contests or pileups where sending accuracy is critical.

Now RoHS compliant, the TVSU-1B can also control external devices such as preamps, active antennas, or external relays that need to have power removed during transmit. Separate power-in and power-out jacks on the front panel are used to control external power in this type of application. Two 2.1 mm power plugs and two 3.5 mm stereo plugs are provided.

**Benefits**
- Control timing of PTT turn-on, hang delay of PTT, amplifier hang delay, external antenna relay hang delay and turn-on delay of auxiliary output
- Dip switch settable delays of 0-30 milliseconds in 2 millisecond steps
- Side tone generator that follows input of keyer or hand key not transmitter
- Side tone pitch can be programmed from 300 to 1000 Hz in 50 Hz steps, front panel headphone jack with adjustable volume
- Supports CW full break in
- Can control external power to our Active Receive Antennas and permit operation in closer proximity to transmit antennas

**DXE-RFCC-1 - Receive Feedline Current Choke, 50 to 75 Ω 300 kHz to 30 MHz**
If you wish to reduce feedline radiation and improve reception, a Feedline Current Choke is recommended if your SWR is already low. Adding a DX Engineering Feedline Current Choke at the point where the feedline exits the area of the antenna will substantially reduce unwanted feedline radiation or reception without the need for improved station grounding.

**The advantages of using an FCC:**
- Prevents unwanted RFI by eliminating feedline current and radiation
- All power goes to the antenna, improving efficiency
- Reduces noise or unwanted signals picked-up by the feedline
- Overcome a less than optimal ground system

The DX Engineering RFCC-1 receive feedline common-mode choke is the most effective solution to common-mode noise or unwanted signal ingress available to date. The DX Engineering RFCC provides thousands of ohms isolation between the input and output coaxial shield connections while passing desired signals, including dc or low frequency ac control signals. The RFCC has extremely high isolation impedance which effectively blocks common-mode noise or unwanted signals, even in the presence of very poor grounding. Low noise receive antennas are traditionally located away from electrical wiring and other noise sources. Unfortunately, noise and other unwanted signals have a direct path to your low-noise antenna through the feedline shield connections between the station equipment and antenna. Unwanted signals can also energize the outside of the feedline shield, and this undesired signal energy can be conducted directly to the receiving antenna. This can reduce antenna directivity. Unless you have a perfect zero-resistance RF ground at the antenna, some of the common-mode noise or unwanted signals from the feedline shield will make it into the antenna. The RFCC is effective from 300 kHz to 30 MHz. It comes with standard CATV type “F” female connectors, although it can be used in any 50 to 75 Ω receiving system. The RFCC is a passive device, therefore requires no power to operate.
**Technical Support**

If you have questions about this product, or if you experience difficulties during the installation, contact DX Engineering at (330) 572-3200. You can also e-mail us at:

DXEngineering@DXEngineering.com

For best service, please take a few minutes to review this manual before you call.

**Warranty**

All products manufactured by DX Engineering are warranted to be free from defects in material and workmanship for a period of one (1) year from date of shipment. DX Engineering’s sole obligation under these warranties shall be to issue credit, repair or replace any item or part thereof which is proved to be other than as warranted; no allowance shall be made for any labor charges of Buyer for replacement of parts, adjustment or repairs, or any other work, unless such charges are authorized in advance by DX Engineering. If DX Engineering’s products are claimed to be defective in material or workmanship, DX Engineering shall, upon prompt notice thereof, issue shipping instructions for return to DX Engineering (transportation-charges prepaid by Buyer). Every such claim for breach of these warranties shall be deemed to be waived by Buyer unless made in writing. The above warranties shall not extend to any products or parts thereof which have been subjected to any misuse or neglect, damaged by accident, rendered defective by reason of improper installation, damaged from severe weather including floods, or abnormal environmental conditions such as prolonged exposure to corrosives or power surges, or by the performance of repairs or alterations outside of our plant, and shall not apply to any goods or parts thereof furnished by Buyer or acquired from others at Buyer’s specifications. In addition, DX Engineering’s warranties do not extend to other equipment and parts manufactured by others except to the extent of the original manufacturer’s warranty to DX Engineering. The obligations under the foregoing warranties are limited to the precise terms thereof. These warranties provide exclusive remedies, expressly in lieu of all other remedies including claims for special or consequential damages. SELLER NEITHER MAKES NOR ASSUMES ANY OTHER WARRANTY WHATSOEVER, WHETHER EXPRESS, STATUTORY, OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS, AND NO PERSON IS AUTHORIZED TO ASSUME FOR DX ENGINEERING ANY OBLIGATION OR LIABILITY NOT STRICTLY IN ACCORDANCE WITH THE FOREGOING.

©DX Engineering 2017

DX Engineering®, DXE®, DX Engineering, Inc.®, Hot Rodz®, Maxi-Core®, DX Engineering THUNDERBOLT®, DX Engineering Yagi Mechanical®, EZ-BUILD®, TELREX®, Gorilla Grip® Stainless Steel Boom Clamps, Butternut®, SkyHawk™, SkyLark™, SecureMount™, OMNI-TILT™, RF-PRO-1B®, AFHD-4® are trademarks of PDS Electronics, Inc. No license to use or reproduce any of these trademarks or other trademarks is given or implied. All other brands and product names are the trademarks of their respective owners.

Specifications subject to change without notice.