

Reflections on Reflectors

A basic tutorial on DSTAR reflectors, by Bob Scott, W6KD

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Reflectors. X-Reflectors. DCS Reflectors. What are these magical things, and how do I, as a DSTAR operator, make use of them?

A DSTAR reflector is an internet server that functions as a repeater—for DSTAR gateways and, in the special case of the X and XLX-reflectors, for other X/XLX reflectors as well. Every arriving DSTAR signal, which appears in the form of a compressed and encoded digital bit stream, is repeated shotgun-style back out to every other connected gateway or interlinked reflector via their internet gateways.

Users can't communicate *directly* with a reflector (remember, it's for gateways only), but they can connect to a repeater, a hotspot, or a dongle-connected computer client that includes an internet DSTAR gateway. The user then sends a command to the repeater, hotspot, or computer client to link its internet gateway to the reflector (and more specifically to a particular module on a reflector). Once that link is established, every DSTAR transmission made through any of the other connected gateways linked to that reflector and module will be sent to the gateway and from there to the user via RF or an internal connection to the user's DSTAR client. A connection to a reflector module is a connection to every other station connected—directly or indirectly—to that same reflector module.

There are four different types of DSTAR reflectors. Their purposes and operation are very similar. The four types are DPlus (aka “REF”) reflectors, X-Reflectors, DCS reflectors, and the newest additions are the XLX reflectors. All share the same basic function described above—they are all internet servers that allow only gateways (and also, in the case of the X and XLX-reflectors, other X/XLX-reflectors) to connect to them, and they serve to bridge together all of the gateways connected to them.

Reflectors are designated and accessed by a three-character type identifier (REF, XRF or DCS) followed by a three-digit number. The XLX reflectors are accessible using one of these three identifiers, but do not have a separate “XLX” identifier. Their modules are designated by a single letter. In the case of the DPlus (REF) and older X-reflectors (XRF), the available modules are A through D, plus a special module E which echoes back the transmissions of any gateway connected to it. In the case of the DCS, XLX and 4th-generation enhanced X-reflectors, modules A through Z are available, with module A of most DCS reflectors linked together and module Z provided as an echo module on the DCS reflectors. A module on any reflector acts as an independent entity...functionally, an REF/XRF is four independent reflectors sharing a common IP address and server, and a DCS/XLX/Enhanced X reflector is 26 independent reflectors using a common IP address and server.

Connecting to a reflector

Connecting to a reflector is done by issuing a command, specific to the repeater/hotspot/client in use, to link that device's internet gateway to the reflector. The most common means are to send a link command via the radio's URCALL field (repeaters and hotspots), to send a DTMF tone sequence from a radio's numeric keypad or menus (repeaters and hotspots), or to select the reflector/module using a GUI or text command (computer client program). In all cases, when using a radio, the RPT1 and RPT2 fields remain set as needed for the repeater/hotspot in use.

To send a link command via the URCALL field, the 8-character field is set up with the reflector name in the first 6 characters, the module name in the 7th character, and the linking command (normally the letter “L”) in the 8th character position. Some repeaters use other characters as a linking command—consult the operating instructions for your local repeater to be sure. So to command a link to XRF555 module D, the URCALL field in the radio is set to XRF555DL, and the radio is keyed for a second or so to issue the command. To link to DCS006 module Y, the command in the URCALL field would be DCS006YL, and to command a link to REF030 module C, the URCALL command would be REF030CL. To unlink the repeater or hotspot from the reflector, send the single character “U” in the 8th character position with blanks in characters 1-7. Some repeaters may use a nonstandard character other than “U” for this function. Once the link is established, reset the radio's URCALL field to “CQCQCQ” in order to communicate. Many hams program their radio memories with presets loaded with the linking commands for the reflector modules they use most.

To use DTMF (dial-tone) codes, the sequence begins with a single digit to identify the reflector type, followed by the three digit reflector number, followed by the single digit module. For the module, a two-digit number corresponding to the letter's ordinal value (i.e. A=01, B=02, C=03...Y=25, Z=26) can be used in lieu of a letter, which is required for module designators E thru Z (there is no corresponding DTMF key past “D”). The first digit for an REF reflector is “*” (star), for an X-reflector it is “B”, and for a DCS reflector it is “D”. So to command a link to XRF555 module D, the DTMF command would be B-5-5-5-D, or alternatively B-5-5-5-0-4 (04 is the same as “D”). To command a link to DCS006 module Y, the command would be D-0-0-6-2-5 (25=Y). To command a link to REF030 module C, the command would be *-0-3-0-C, or alternatively *-0-3-0-0-3 (03=C). To command unlinking, send the “#” digit. For those using radios without DTMF pads but which have DTMF menus in the radio, a 200ms dial tone burst rate works well with most repeaters and gateways. Too fast can be an issue. Last, some software (e.g. G4KLX gateway) allows abbreviations of the DTMF reflector codes...see the application docs for specifics. In all cases, though, use of the full code as described above works.

Reflector protocols

There are three protocols used by the various user gateways to communicate with reflectors. In an ideal world this would be transparent to the user, but there are some issues to be aware of here. The three protocols are DPlus, DExtra, and DCS.

The REF reflectors were the first to appear. They use the DPlus protocol to communicate back and forth between the gateways. The user generally need not do anything special to facilitate this working, unless there is an unusual firewall configuration (sometimes seen in commercial/government networks).

The DCS reflectors use their own protocol, and any gateway software which allows connection to DCS reflectors has that protocol built-in. No special firewall configuration is needed to allow DCS connections.

The XRF and XLX reflectors have another available protocol, known as DExtra, but they both can also use the DPlus protocol used by the REF reflectors. *If the gateway is configured to use the DPlus protocol when connecting to an XRF (as is the default with DSTAR Commander and possibly some other software packages), no special router configuration is needed.* For users of DSTAR client programs such as WinDV, the connection type must be changed from DExtra to DPlus when a gateway connection is configured if the user desires to take advantage of the universal connectivity of DPlus.

If a DExtra connection is specified by the gateway, there can be a problem, in that the basic DExtra protocol (DExtra as used by 4-module X-reflectors and XLX reflectors) requires some special firewall/router configuration if used (DPlus does not). If the basic DExtra protocol is used, then port 30001 must be open for inbound connections, which does require port forwarding be enabled in the user's router/firewall to work.

The newest 4th-generation X-reflectors (most easily identified by the presence of 26 modules A-Z on the dashboard) use a modernized version of DExtra (aka DExtra Enhanced) that allows you to connect using DExtra through firewalls without any special router configuration.

Bottom line: when connecting to any reflector other than a DCS reflector, DPlus is a universal option that works without additional router configuration. DCS is required for DCS reflectors and also works without needing any special router configuration.

Functional comparison between reflectors

Bottom line, all four reflector types perform the same function—to bridge gateways to interconnect a large cluster of DSTAR gateways. Here are some characteristics and pros/cons of each:

REF reflectors are all centrally administered by the reflector software's author. He exercises strict personal control on the configuration of every REF reflector, allowing only himself access to the servers and their configurations. The software is closed-source, and connections to other linked systems are not supported.

DCS reflectors are also centrally administered, and the reflector software is also closed source. This system is predominantly deployed in Europe, though there is at least one DCS reflector (DCS006) serving the USA. There are 26 modules on each DCS reflector with one designated as an echo module. Module A is cross-linked between most of the DCS reflectors (common calling channel)

X-reflectors are operated by independent operators and run using free open-source software. They can be (and are) interconnected experimentally or persistently with other systems and networks (e.g. analog bridge, ALLSTAR, IRLP etc) X-reflectors can be interconnected between themselves or with XLX reflectors to form easily configured subnets or to distribute load should a single XRF approach congestion. The new 4th-generation X-reflectors have 26 modules and no echo module; the older ones have five, including an echo module (module “E”).

XLX Reflectors are also open source and operated by independent operators, and also support interconnection between themselves and the X-reflectors. The XLX reflector has the most cross-protocol functionality, as it can support DPlus, DExtra, and DCS protocols. XLX reflectors can be accessed as REF, XRF, or DCS provided the gateway host file has each “flavor” defined separately. For example XLX313 can be accessed as REF313 if it is defined in the DPlus hosts file in the gateway, can also be accessed as XRF313 if that is defined in the DExtra hosts file, and also as DCS313 if defined in the DCS hosts file.

Software specific limitations on reflector use

Not all DSTAR gateway software is capable of linking to all types of reflectors. Here are some known software packages and their limitations as applicable:

G4KLX (for Linux/Windows) (Includes DSTAR Commander and WesternDStar images) Can access all types of reflectors, and when specially-configured (for example the DSTAR Commander image incorporating the G4KLX suite), no port configuration is needed for XRF access. Very popular on the Raspberry Pi and other inexpensive single-board nanocomputers.

WinDV/dvNode (Windows only) Can access all types of reflectors. Defaults to DExtra for XRF links, but can be manually configured for DPlus protocol for connections to XRF (easily done in GUI).

KI4LKF (Linux) – Free*Star is a variation of the KI4LKF gateway software. Can access all types of reflectors.

dvTool/DVAPTool (Linux/Windows/Mac) – Access to REF reflectors only. An earlier version could be made to allow XRF access through a modified windows host file—current version does not allow XRF access with the Windows host file mod.

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