Mitigating VEXNet Connection Issues

(What You Need to Know)

Many of the BEST Robotics competitions have had multiple occurrences of interruptions in robot performance on the field. Teams and hubs attribute these interruptions to RF interference and the VEXnet losing the connection between the team's joystick and their robot. What is interesting is that these issues rarely occur at any of the Robot Education and Competition Foundation (RECF) events. RECF hosts >2000 events per year yet they have had less than 10 legitimate connection problems at those events. Just what is going on?

BEST Robotics and VEX Robotics met earlier this year to try to understand what was happening and what could be done to lessen the impact at BEST Robotics events. We've documented the results of this meeting and combined those with inputs and observations from our own kit experts.

Each of the suspected issues/causes is addressed below. Just FYI, at the RECF competitions, 100% of the few issues they did have were directly related to power management ➔ loose wires, bent keys, power thermal coupler (PTC, i.e. the "circuit breaker"), poorly seated (loose) keys, and/or low batteries.

<u>Loose Battery Connection [Team Action]</u>

Any interruption in power causes a VEX Cortex reboot and a VEXnet reset. We suspect this issue is the number one cause of problems for teams and most don't know it. If a wireless drop occurs, the VEXnet will normally reacquire in 5 or so seconds. If recovery takes more like 20 seconds, it is a VERY good chance that the Cortex experienced a power interruption due to poor battery to Cortex connections. It takes that long for the Cortex to reboot and re-establish the VEXnet connection with the joystick.

Students often remove the battery off the charger by pulling on the battery (as opposed to pulling the connectors apart). This means the wires get pulled out of the connector or the battery, causing the batteries to fail.

Diagnoses: With the Cortex turned on, jiggle the power wires/connectors. If the power is interrupted, isolate the issue and fix it. The most common issue here is at the Cortex Molex connector.

RF Interference [Team and Hub/Regional Actions]

The VEXnet system operates on the 2.4 GHz band of the radio frequency (RF) spectrum. Many other devices also operate in this same band. In particular, most Wi-Fi devices operate in this band. The following steps are the recommended to avoid potential interference problems.

- Venues need to block the WIFI channel used for the competition. Channel 1 and 6 (non-Game Mode channels) or 11 (Game Mode Channel) needs to be blocked and then the blocked channel/s can be used for the competition. [venue and hub/regional action]
- If the venue has an open Wi-Fi network, ask if they can set it up to be protected (as in need a password to use it). This puts only the game scoring hardware using the WiFi. This step will help by cutting down on the traffic that is flowing over the network. [venue and hub/regional action]
- Shut down venue Wi-Fi routers, if possible [hub/regional/venue action]
- Any wireless microphone on 2.4 GHz may interfere with VEXnet(s). Microphones in the venue should use the 5 GHz frequency. [venue and hub/regional action]
- Have robots in the pits use tethered operation [team and hub/regional action]
- Have someone monitor Wi-Fi network and Bluetooth activity. [Hub/regional Action]
- Ask attendees to not use Wi-Fi, or more specifically, turn off WiFi on their devices. Have signage and make announcements about no Wi-Fi or streaming. [hub/regional action]
- Only use wireless A/V equipment that operates on other frequencies [hub/regional and venue action]
- Monitor the 2.4 GHz channels for Wi-Fi activity (free options: Inssider 2.1.6.1394 for PC; WiFiAnalyzer for android) [hub/regional action]
- If you are using the Game Mode dongles, place the dongle in the Joystick unit. Power up the Cortex and the Joystick to confirm Game Mode and VEXnet connectivity. Make sure that dongle is securely fitted in the joystick unit. We've seen poorly connected dongles drop on the floor while the driver walks to the field to start the match. [Team Action]
- If the robot is going to be using an on-board recording device (like a GoPro or a phone), verify that the device is not streaming when it is recording. GoPro Bluetooth should be turned off, phones should have WiFi and Bluetooth disabled. Verify no Bluetooth or Wi-Fi streaming with the appropriate monitoring apps if necessary. If a network/stream pops up when the device is turned on or when it is recording, have the team turn off the device and remove it from their robot. The best approach is to have one knowledgeable person dedicated to this task. [hub/regional staging crew action]

Even if these steps are not taken, it is very possible that you may have no interference issues. In general, it requires a strong RF signal operating on the same channel as the robots to cause an issue. The robots' default frequencies are common to Wi-Fi Channels 1, 6 and the bottom

end of 11. So, if other devices are kept off these channels or kept at a long enough distance, interference issues are unlikely. The typical 2.4 GHz culprits for interference are the venue house routers (that are on or overlap Channels 1, 6 or 11) or a device that is streaming nearby to the robots. Note that some wireless devices operate on a single channel and some operate across some or all of the channels. Also note that it is possible for devices that share the same frequency as the robots to not cause any issues if they are not actively transmitting data (as in they are relatively "quiet").

A wireless drop usually recovers in 5 or so seconds. If it takes much longer, look for a power management problem.

The alternate "Game Mode" VEXnet frequencies fall into Wi-Fi Channels 11 (upper end) and 14. Note that a Game Mode dongle must be plugged into the VEX Joystick in order to toggle the unit into "Game Mode". Also note that Wi-Fi Channel 14 was banned for use by Wi-Fi devices in 2005 (FCC regulation). Therefore, Wi-Fi interference should not be an issue on Channel 14. There are other devices that operate in Channel 14 bandwidth, like VEXnet, but traffic there should be light.

Bent VEXnet Key [Team Action]

Bending the key is BAD! Some teams, when they pull the key from the Cortex or the joystick, put an upward strain on the key when they pull – in other words they pull up and out rather than just straight out. This will (or eventually will) cause connection issues.

A bent VEXnet Key is often a sign of abuse; the keys get pried on when being extracted as opposed to getting pulled straight out. Prying the key up or to the side bends it and can cause the key to fail due to damage to the internal circuitry. If one of your team's keys is bent, find out from your hub if you can get a replacement key.

Poor Battery Management [Team Action]

A low robot battery or low joystick batteries can lead to a connection drop. They can certainly lead to poor robot performance during a match. Make sure batteries are properly and fully charged before your next match.

Loose (Poorly Seated) VEXnet Key [Team Action]

A poorly seated key in the Cortex may lose connection as the robot travels the field or the driver uses body language to help out robot steering. Even a wiggle of the key may cause a lost connection. Some teams use a rubber band to keep the key seated and plugged in.

Diagnoses: With the Cortex and joystick turned on and an active VEXnet connection established, jiggle each VEXnet key. If the VEXnet connection is lost, address the loose connection.

VEXnet Key Performance [Hub Action]

Diagnoses: Intermittent VEXnet connection drops. Greater occurrences as the distance between the Joystick and Cortex is increased. If you swap the keys out and the problem goes away, you probably had an antenna set that was performing at the lower end of the specification range. It also possible that the dropouts are strictly a RF interference issue or combination of key performance and RF issues.

The performance of a given set of keys can be "measured". In a quiet RF environment, establish a VEXnet connection between the Joystick and Cortex and then slowly back away until the connection is lost. Do this for each set of keys. If any key set loses connection in less than 40 feet, we recommend pulling them from your inventory. If a key set fails this test, try pairing each key with another key and repeat the test. It is unlikely that both keys are performing poorly. Note that for BEST, we only need to operate at a maximum distance of 34 feet, but hubs should give some margin here.

VEXnet Key Failure [Team Action]

VEXnet key failures are normally a hard failure. As in no connectivity as opposed to intermittent connectivity. If you can't get a connection at all, try re-establish the pairing between the Joystick unit and the Cortex unit by connecting them with a USB cable. If you still can't get a connection with the keys after that, try different keys to see if they work. The last step to try on "failed" keys is to reload their firmware and try them again.

Old VEX Keys [Hub Action]

Old VEX keys, version 1.0, will not work. Hubs should already have swapped their old keys for the 2.0 keys.

Old Low-Rise Cortex Units [Hub Action]

The initial production units of the Cortex had the VEXnet key placed in close proximity to the microprocessor. The EMF from the microprocessor reduced the radio range of these units. The current Cortex units do not have this issue. A work-around for these old units in to use to USB extender cable (up to 18" is allowed) for the VEXnet key. Hubs should replace these Cortex units or provide the USB extender cables in the returnable kits.

Cortex Thermal Limiter (Power Thermal Coupler or PTC)

This cause may act like a VEXnet connectivity issue, but it is not. Running into the field or pushing heavy items across the field for very long can pull 100% of the current into one PTC. If the Cortex thermal limiter trips due to high current draw, all motors on that circuit bank will stop working (e.g., fail to respond). VEXnet maintains connectivity, but the robot will not move until things cool off a bit such that the limiter resets. The time to reset depends upon how warm/hot the limiter got.

On the Cortex, ports 2 through 5 are feed into one thermal limiter, while ports 6 through 9 feed into a second thermal limiter, and 1 and 10 are left on a smaller limiter (ports 1 and 10 are not

used by BEST). We highly recommend that teams not put all drive motors into a single bank of ports. [Team Action]

Poor Power Management While Driving

Some teams drive their robot hard and long or try to push heavy objects for a fair amount of time. These driving methods pull lots of current from the battery on the robot. Spiking power needs and diving battery current may create a "brown out" on the Cortex. In other words, if you drive your robot hard and your motors pull too much current, your battery may not have enough to power the Cortex, too, causing a reboot. Teams should practice good driving habits with their robot and make sure their battery is fully charged before each match. [Team Action]

