Technical Service Bulletin 040831
Troubleshooting Crowbar Events: IOX/DCX

Perhaps the most frequent problem encountered in any IOT-equipped transmitter is arcing in the high voltage circuit powering the IOT. Because this arcing typically causes the crowbar protection circuit to fire, it is often synonymously known as “crowbarring”. The causes for this high voltage arcing can be quite varied, from the catastrophic destruction of a high voltage insulator to random static discharges associated with corona.

Troubleshooting the high voltage circuit is somewhat difficult due to the rapid and violent nature of the failure event and impossibility of seeing or touching the components under high voltage as the failure occurs.

> **NOTE:** For the purposes of this bulletin, the high voltage circuit is described as the ensemble of components normally placed under high voltage while the IOT is operating: the beam supply, crowbar assembly, HV isolation relay, Filament/Bias/Ion (FBI) supply, IOT input cavity, IOT itself, and the wires connecting these assemblies together in a circuit. Consult schematic 451890 in chapter 12 of the HPA manual for a schematic of high voltage circuit in the high voltage compartment.

This bulletin provides a systematic procedure for troubleshooting the high voltage circuit in Comark IOX/DCX Series of television transmitters. Before attempting to implement this procedure, the reader is invited to consider the following important items:

1. **Observe proper high voltage procedures at all times.** The high voltage present the high voltage circuit can cause serious electrocution or death. Never defeat any interlock protection circuit when attempting to diagnose a problem. Always use the supplied grounding hooks to ground all high voltage components before attempting to come in contact with them. Do not attempt this implement this procedure until you have read this bulletin in its entirety and fully understand the engineering principles underlying it. Consult Service Bulletin 940911 for more information on proper high voltage safety procedures.
2. **Comark strongly recommends that all of its IOT customers purchase a high voltage test set (hipotter).** These units are relatively inexpensive and greatly simplify the troubleshooting process. Several recommended units are the *Spellman SL300N60*, *Hipotronics 880PL*, and the *Glassman FC50N2.4 with CT option*. More information on these units may be found on the Internet. For more information on high voltage troubleshooting with a hipotter, please consult Service Bulletin 030614.
3. **The successful application of high voltage for even a second, even once, indicates a flashover in air or a vacuum.** Breakdowns in a solid material are immediate and irreversible. A voltage breakdown in a solid material, such as the high voltage insulator in the IOT input cavity, will cause an immediate arc each and every time the high voltage is applied. A high voltage arc through a non-solid material, such as a static discharge through air or an electronic avalanche inside the thyratron or IOT, may be immediate or may be random and erratic.

4. **The motorized breaker may be weakened by frequent crowbar events.** This is especially true of the smaller CB3 breaker contained in IOX and non-millennium DCX transmitters. A failed motorized breaker will cause a “Soft Start Failure” alarm on the HPA control panel, or possibly low beam voltage with excessive sag under load, due to a missing phase in the 480V feeding the beam supply primary. An improved motorized breaker is available for the IOX and non-millennium DCX transmitters. Consult Service Bulletin 040321 for more details.

Procedure 040831: IOT Crowbar Event Troubleshooting Procedure	
Applicability	All IOX and DCX transmitters.
Prerequisites	Transmitter in HPA Start Mode and ready to have beam voltage applied.
Equipment Required	Hipot test set strongly recommended.
Comments	First tier troubleshooting procedure when IOT suffers frequent crowbar events. Consult schematic 451890 in chapter 12 of HPA manual for schematic of high voltage circuit to gain better understanding of procedure.

NOTE: This procedure assumes that the amplifier cabinet in question is arcing under DC conditions. If arcing occurs only while the amplifier cabinet is transmitting at full RF power, some care must be taken to ensure that a transient overdrive condition, possibly due to an intermittent RF connection, is not overloading the IOT. One way to check for the presence of overdrive transients is to reduce the RF output power to 10% and observe the power level stability while flexing or gently tapping various cables and components in the lower level drive circuits.

1. Place high voltage isolation relay in ISOLATED position.
2. Press Beam Mode button on HPA control panel to activate high voltage.
3. If high voltage holds with isolation relay in ISOLATED position, problem is after isolation relay in high voltage circuit. Skip to section ***Arc After High Voltage Isolation Relay*** later in this procedure. If crowbar fires and/or motorized breaker trips with isolation relay in ISOLATED position, problem is before isolation relay in high voltage circuit. The most likely causes of a problem occurring before the isolation relay are:
   - Pre-firing thyratron either due to excessive thyratron filament voltage *(40% probability)* or possibly exhausted (end-of-life) thyratron tube *(30% probability)*.
   - Static discharges from jacket of red HV wires to ground *(10% probability)*.
   - Internal short in capacitor C1 on rear wall of high voltage compartment *(10% probability). (where applicable - C1 not present on certain DCX transmitters)*
   - Other causes *(10% probability).*
4. Gain access to high voltage compartment via key interlock system, ground all high voltage circuits using HV ground hook, and remove plug P4 from jack J4 (LOAD) on upper (HV) section of crowbar assembly. Re-route lead with plug P4 such that it remains at least four inches away from upper half of crowbar assembly and any other circuits to be energized. Close high voltage compartment and repeat application of high voltage. If high voltage holds with plug P4 removed, problem is between crowbar assembly and high voltage isolation

relay. Repeat test with resistor R2 or isolation relay disconnected to determine faulty component.

5. If high voltage does not hold with plug P4 removed, gain access to high voltage compartment via key interlock system, ground all high voltage circuits using transmitter ground hook, re-insert plug P4 into connector J4, and remove plug P3 from connector J3 (LINE) on upper (HV) section of crowbar assembly. Re-route lead with P3 such that its exposed point remains at least four inches away from all metal surfaces. Mechanically support lead with plug P3 to keep it from falling after high voltage compartment is closed and high voltage is applied. Use cable tie several inches back from plug P3 to fasten cable to crowbar assembly chassis and allow plug to float in space.
6. Close high voltage compartment and attempt to reapply high voltage. If high voltage holds with plug P3 removed, problem likely due to thyratron pre-firing due to either thyratron filament overvoltage (especially if crowbar assembly or thyratron was recently replaced) or an end-of-life thyratron. Measure thyratron filament voltage per procedure in Service Bulletin 030605. If filament voltage is greater than 6.3 volts AC, lowering filament voltage may eliminate pre-firing problem. If filament voltage was already below 6.3 volts AC, thyratron will most like require replacement. Contact Comark or thyratron manufacturer to order replacement.

> **NOTE:** A very rare problem has been observed in which the crowbar instantly FIRES but does not TRIGGER (as viewed on the HPA control panel) upon the application of high voltage, and the motorized beaker does not trip. This problem is believed to be due to the partial failure of a beam supply capacitor creating an erratic high voltage rise-time, which in turn causes a spurious avalanche in the crowbar thyratron. Contact Comark Customer Service if you observe these unusual symptoms.

7. If high voltage does not hold with P3 removed, open high voltage compartment and verify the lead with P3 has not slipped and approached or touched ground. If P3 lead is still intact, problem may be due to a failure of capacitor C1 at the rear of the high voltage compartment. Attempt to reapply high voltage with C1 disconnected to verify high voltage standoff capabilities of C1.

> **NOTE:** Capacitor C1 is not present on some DCX amplifier cabinets. DCX cabinets do not require C1, and this capacitor may be safely removed from all DCX transmitters.

8. If high voltage does not hold with C1 removed, arcing may be due to one the following problems in the beam supply or high voltage conduit run to the HPA cabinet.
   - Punctured high voltage insulation or water inside HV conduit from beam supply *(40% probability).*
   - Water in beam supply *(30% probability).*
   - Shorted diode pack in beam supply oil tank *(10% probability).*
   - Shorted capacitor in beam supply *(20% probability).*

NOTE: Since the body current metering circuit measures all ground fault current regardless of origin, many of these problems in this section will cause the transmitter to instantly shut down on a simple body current fault before a trip of the motorized breaker can occur. Also, because these faults occur before the crowbar assembly in the high voltage circuit, the crowbar should NOT fire when these faults occur. Note that the body current circuit may be defeated in those cabinets equipped with an IOT model featuring a grounded collector.

9. Gain access to beam supply via key interlock system, ground all high voltage circuits with HVPS grounding hook, and inspect for signs of water, bulging high voltage capacitors, or other abnormalities. If no obvious signs of damage are apparent, use wrench to disconnect red HV wire from HV OUTPUT (-) lead. Close beam supply and reapply high voltage. If high voltage holds (breaker does not trip) with (-) output lead removed, problem is in high voltage conduit run to HPA cabinet. Check for presence of moisture in conduit run, and replace HV wire run from beam supply to HPA cabinet as necessary.

NOTE: Since the high voltage no longer reaches the metering divider in the HPA cabinet with the (-) output lead disconnected, there will be no beam voltage reading in the next few steps. High voltage will be considered to be successfully holding if the motorized breaker does not immediately trip when the transmitter attempts to enter beam mode.

10. If high voltage does not hold with (-) output lead removed, repeat test with each high voltage capacitor disconnected. If high voltage holds with a certain capacitor disconnected, replace defective capacitor.

11. If high voltage does not hold with all high voltage capacitors removed, open transformer oil tank, disconnect AC feed to diode transpacks, replace cover, and attempt to reapply high voltage. If high voltage holds, contact Comark to order new diode transpack. If high voltage does not hold, transformer windings may be shorted. Contact Comark.

NOTE: Additional information on testing individual diode transpacks: Remove diode transpacks from oil tank and test each pack using a variable DC bench power supply connected across pack. Diode pack should conduct approx 0.5 amperes @ 30 volts in forward direction and virtually no current in reverse direction. Replace diode transpack if shorted. Measure voltage drop of each individual diode in forward direction to determine if any individual diodes are shorted or open.

Arc After High Voltage Isolation Relay

12. If high voltage holds with high voltage isolation relay in ISOLATED position, arcing is occurring in one the following locations after the isolation relay:
    - Electronic avalanche inside IOT due to ionized gas molecules *(45% probability).*
    - Breakdown of insulation material in IOT input cavity *(25% probability…especially if consistent and immediate).*
    - Breakdown of insulating ceramic between IOT grid and anode *(5% probability).*
    - Flashover in junction box connection area *(5% probability).*
    - Punctured insulation in high voltage wire(s) between FBI assembly and IOT *(5% probability).*

- Static discharge from jackets of high voltage wire between FBI assembly and IOT *(5% probability…especially if random and infrequent).*
- Breakdown of insulation inside FBI isolation transformer *(5% probability…especially if consistent, but only after a fifteen minute warm-up period).*
- Flashover across FBI standoffs or other insulator due to dust, corona buildup at sharp points, etc. *(5% probability).*

NOTE: Additional note for Comark brand IOTs: Comark IOTs have an additional input tuning adjustment for neutralization. If this adjustment is not set correctly, the tube can break into spontaneous oscillations. The immediate surge in beam current from such an oscillation can fool the crowbar's sensing circuitry and cause a spontaneous crowbar TRIGGERED and FIRED event before a beam current overload can be registered by the HPA controller. A telltale sign of this phenomenon is a crowbar firing NOT accompanied by a trip of the motorized breaker, occurring only in the HV CONNECTED mode. This scenario is most likely to occur after the replacement of a Comark input cavity, especially if proper tuning procedures have not been followed.

13. Set bias voltage to highest setting to pinch off beam current conduction in IOT. Attempt to reapply high voltage to IOT. If high voltage holds, allow IOT to remain in this condition for five minutes, then lower bias voltage by five volts. Lower bias voltage in gradual five-volt steps until IOT regains original bias voltage setting. Consult Service Bulletin 030525 for more instructions on how to adjust bias voltage.

NOTE: If ion current is observed at any point in this process, allow ion current to fully drop to zero before proceeding to next adjustment. Do not attempt to apply high voltage unless ion current is at or very near zero. The IOT will typically arc with any ion current above 5uA. If ion current reading fails to drop below 5uA threshold after fifteen minutes, ion supply or IOT itself may be faulty. Consult Service Bulletin 030328 for suggestion on ion pump troubleshooting.

14. If high voltage does not hold, or holds for only brief periods of time, take additional step of lowering beam voltage to its lowest tap setting. Attempt to reapply high voltage to IOT. If high voltage holds successfully, slowly return beam voltage, then bias voltage to original settings. Consult Service Bulletin 030611 for more information on how to adjust beam voltage tap setting.
15. If high voltage does not hold, or holds for only brief periods of time, take additional step of lowering the IOT filament voltage to 0.5V below its nominal setting. Attempt to reapply high voltage to IOT. If high voltage holds successfully, slowly return filament voltage, beam voltage, and bias voltage to nominal levels. Consult Service Bulletin 030524 for more instructions on how to adjust filament voltage.
16. If crowbar has consistently and instantly fired on each and every application of high voltage in last three steps, problem is likely due to a catastrophic and irreversible breakdown of high voltage insulation in IOT umbilical, IOT input cavity, or IOT itself. Beyond this point, further troubleshooting will be greatly facilitated by the use of a high voltage test set (hipotter). Comark strongly recommends that all of its IOT customers purchase a hipotter. These units are relatively inexpensive and greatly simplify the troubleshooting process. Several recommended units are the *Spellman SL300N60*, *Hipotronics 880PL*, and the *Glassman FC50N2.4 with CT option*. More information on these units may be found on the Internet.

For more information on high voltage troubleshooting with a hipotter, please consult Service Bulletin 030614.

17. If no hipotter is available, gain access to high voltage compartment via key interlock system and ground all high voltage circuits with transmitter grounding hook. Carefully inspect high voltage wires and neighboring metal surfaces for signs of arcing. Clean dust from all high voltage wires and neighboring metal surfaces. Inspect all high voltage wires for signs of perforated insulation.
18. Open tube junction box and carefully inspect for signs of arcing (where applicable). Clean all dust from the junction box.
19. Attempt to reapply high voltage to IOT. If arcing persists, contact Comark Customer Service.

NOTE: Comark offers rental hipotters for the rate of $100.00/day. Please contact Comark Customer Service for more details.

At Comark, we are constantly striving to improve the satisfaction of both our new and existing customers. Please do not hesitate to contact Comark Customer Service with any questions you may have concerning the contents of this service bulletin.

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