VIA Rail HEP Requirements

By ERIC WILDE

The requirements for operation of private cars on VIA Rail trains (both LRC and HEP I/II) are described herein. Essentially, it is possible to operate an Amtrak-compatible car on a VIA Rail train with very little investment in electrical modifications, given a basic understanding of how the VIA system works. The simple steps to follow for trouble-free operation are enumerated after a discussion of the details of the system.

With the recent upsurge of interest in operating private cars in Canada, both from the point of view of VIA Rail and the American private car owner, it seems like a good time to discuss the differences in the two HEP systems employed by Amtrak and VIA. The focus of this article will be on providing a basic understanding of the VIA HEP system and how its features affect the operation of an Amtrak-compatible private car on a VIA train.

While the Amtrak and VIA Rail HEP systems are similar in many respects, they are dissimilar enough that an Amtrak-compatible car cannot simply plug into a VIA train and go. On the other hand, there are no insurmountable difficulties that prevent the operating of the two types of cars together.

Similarities

As I noted, in many respects, the two HEP systems are quite similar. They both use 480V, three-phase power with the phase rotation proceeding around in the same direction. The trainline plugs are the same in number and type, the locations of the plugs and connectors are in close proximity to one another and their configuration is similar.

The number of trainline conductors used and their current carrying capacity are identical. Thus, the consist limits, with respect to the amount of power used, are more or less identical although VIA's vinter heating loads are undoubtably much greater and Amtrak's summer cooling loads are probably much greater.

The number and type of wires used in the HEP control circuits are the same as are the principles employed (e.g. trainline continuity and ground fault detection). There are minor differences in the pins used for the control functions but these are easily accounted for.

Design Goals

Amtrak was one of the pioneers in the use of HEP for the heating and cooling of passenger trains in North America (although not strictly **the** pioneer because several HEP systems already existed on various commuter railroads and even the long distance service operated by CN between Toronto and Windsor with its Tempo fleet). The primary reason for the adoption of HEP by Amtrak was because steam heat proved to be so unreliable and such a pain to make work in this modern day and age. Clearly, an all-electric system would be vastly superior.

The criteria for the Amtrak HEP system's performance were set by the operating environment. Trains would experience a range of ambient temperatures (often during a single trip) and operate over the entire 48 states (or nearly so). While I was not a party to the thinking that went into the design process, it appears to me from examining the design that the decision was made to implement a moderately robust system that followed those in use on several of the commuter railroads. The desire to use standard, off-the-shelf components appears to

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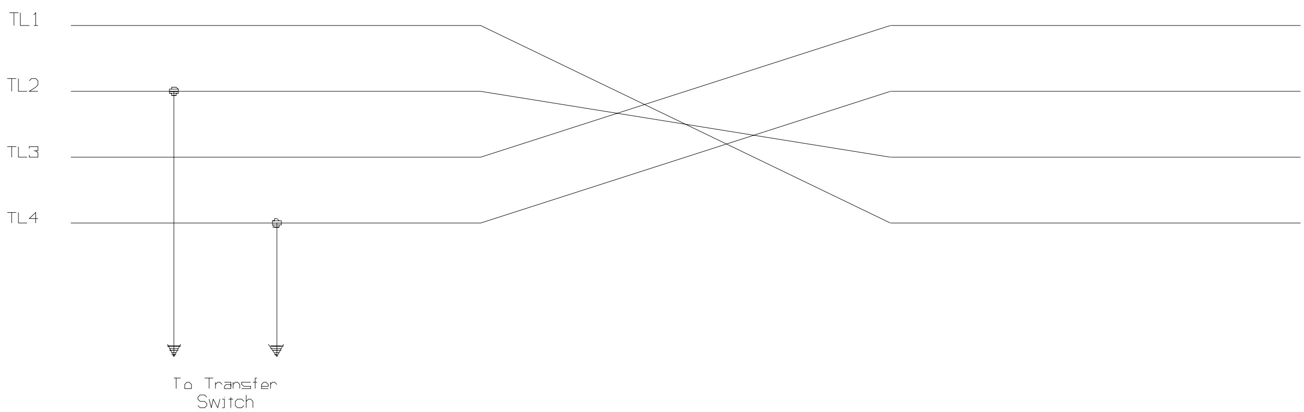

Figure 1: VIA Rail Trainline

have played a significant part in the design decisions made.

VIA Rail is faced with much colder wintertime temperatures over a much greater portion of the country than Amtrak is. In addition, one could successfully argue that a significant chunk of the rail network passes through the remotest boondocks. Although I was, once again, not party to the thinking behind the decision-making process, I perceive that a much greater emphasis was placed on reliability in the system design, perhaps because VIA realized that freezing a trainload of passengers to death in North Boondock, Ontario would lead to bad press. Maybe the operational experience gained by Amtrak also had something to do with the design.

Whatever the case may be, the VIA Rail HEP system has a much greater number of features in its design that could be considered reliability features. The consequent costs are undoubtedly worthwhile in a land where buildings freeze solid from the fire department’s water before the fire can burn them to the ground (I’m not making this up -- I’ve seen it in person and it is a **very** weird sight).

Differences Between VIA and Amtrak

The two principal differences, between the VIA and Amtrak HEP systems, that must be addressed are: (1) the fact that VIA splits their trainline into two parts while Amtrak’s trainline is a single entity; (2) the fact that the ground and trainline complete circuits in the two trainlines are different.

Amtrak’s HEP system is simplicity itself. 480V, three-phase power is passed from car to car through four sets of 4/0 cables (with three conductors in each set for a total of 12 conductors all told). All of the cable sets are tied together (or more correctly, each of the three phases from the four sets) at a junction box in the center of each car. Power to run the car is drawn from this junction box. Tying all of the phases from the four sets together ensurers that the load is spread out over each set and that no one set of cables hogs the load (due to slight variations in length and, hence, resistance). In the mean time, phase balance is maintained by Royal fiat.

On HEP I/II (refurbished CPR “Canadian”) equipment, VIA Rail splits the 480V trainline into two sides, left and right. This is done so that two locomotives can supply the trainline, thereby providing more power for heating. Should Amtrak wish to do something like this, they would need to phase the two locomotive's generators, not a simple task. By splitting the trainline into two pieces VIA neatly avoids the need for phasing the two generators. The split trainline also adds redundancy but we'll get into that later.

On each HEP I/II car the sets of cables in the trainline are swapped from left to right and flip-flopped so that, numbering from the left, looking at a car's B-End, the trainline sets TL1, TL2, TL3 and TL4 become TL4, TL3, TL1 and TL2 respectively (see Figure 1). From the standpoint of a train, passing through four cars, TL1 becomes TL4, then TL2, then TL3 and back to TL1 on the fifth car.

If you study this arrangement, you'll see that the two pairs of trainline sets swap back and forth from left side to right side on each car. In addition, TL1 and TL2 are flip-flopped on each car.

According to the VIA Rail wiring drawings, each car normally draws power through a transfer switch from the left side trainline set TL2. Thus, on a four car train the first car draws power from TL2, the second from TL4, the third from TL1 and the fourth car from TL3. After four cars, the pattern repeats itself. Between each pair of cars, one draws power from the left trainline and one from the right. When a single locomotive is supplying the train, the load is balanced across all four trainline cable sets. When two locomotives are supplying the train, the load is spread evenly over the left and right trainline groups.

Within each trainline cable set, the phases are rotated (direction of phase rotation is maintained) so that A becomes B, B becomes C and C becomes A. This has the property of spreading any unbalanced single phase loads out across all three phases. What Amtrak achieves by Royal fiat, VIA achieves electrically.

The interesting part of VIA Rail's HEP system is how it deals with faults. On a long train or on one passing through northern Canada, if two locomotives are present, one will be used to power the left side of the trainline and the other will be used to power the right side. As I said before, this doubles the power available without the need for phasing the generators. Power is drawn equally from the left/right sides so that the load is balanced.

Should one HEP generator die, rendering either the left or right side of the trainline dead, an automatic transfer switch within each car will switch those cars not already connected to the remaining live side of the trainline to it. No car goes without power.

Meanwhile, the load on the remaining side of the trainline is now doubled. To deal with this, a set of load shedding relays on each car disconnects approximately half of each car's heating load. This happens whenever the relays detect a loss of power on either side of the trainline. It may get a little cool on-board (and this can be compensated for by slowing down to reduce wind wipe) but nobody freezes to death.

Finally, one must examine the control circuits within the trainline for compatibility issues. The purpose of the control circuits is twofold: ground fault detection; and continuity detection.

Ground faults are detected by tying all of the frames of the cars in the train together through a ground wire in the control cable. A set of sensors in the locomotive measures the potential (i.e. voltage) between this ground wire and each of the three phases in the trainline. If a single phase goes to ground in any car, a voltage will appear on the ground wire in the locomotive. The ground fault detection circuits, sensing this voltage, will trip the main breaker. It is possible to set the ground fault trip potential to a small value (below 48V is always safe) so that leaks as well as hard ground faults are detected.

Continuity faults are detected by running a single wire through all of the trainline connectors, alongside the power wires. By checking for continuity through this wire, one can trip the main breaker if a loss of continuity is detected. By designing the trainline connectors with the control pins physically shorter than the power pins, it is possible to cause the trainline power to shut down before contact on the withdrawing power pins is broken, thereby avoiding arcing.

Normally, for the purposes of continuity detection it is only necessary to use a single wire in the trainline continuity circuit. The continuity circuit starts out at the locomotive and continues through all of the right connectors of the right trainline to rear of the train where it loops back around through the left connectors of the right trainline. When it reaches the locomotive, it crosses over and runs down and back through the left connectors of the left trainline followed by the right connectors of the left trainline. On both Amtrak and VIA equipment, Control Pin 1 performs this function.

For the purposes of ground fault detection, it is only necessary to tie all of the car frames together with a single wire. It is over the use of this wire that VIA and Amtrak differ. VIA uses Control Pin 3 for ground while Amtrak uses Control Pin 2. Consequently, if ground fault detection is to continue to work, the wires leading to Control Pins 2 and 3 must be swapped between the VIA and Amtrak-compatible cars.

In addition to the different Control Pins used for ground fault detection, Amtrak uses the circuit on Control Pin 3 as a secondary continuity detection circuit. VIA, on the other hand, uses the circuit on Control Pin 2 as a secondary continuity detection circuit. On top of this, the routing of the wiring connected to Control Pin 3 on an Amtrak-compatible car is different than the routing of the wiring connected to Control Pin 2 on a VIA car. The fact that Control Pin 2 is grounded on an Amtrak-compatible car while VIA Rail is expecting to use the circuit found there for continuity detection presents a problem. Swapping the wires leading to Control Pins 2 and 3 will only satisfy the VIA Rail continuity detection circuit connected to Control Pin 2 if the three corners of the Amtrak-compatible car or cars that are not plugged into the VIA consist are properly looped back or short-looped.

The differences between LRC and HEP I/II equipment are interesting to study by not particularly relevant. Essentially, the LRC trainline is split into left and right sides but the sides do not cross over from left to right between cars as they do on the HEP I/II cars.

Note that I am purposefully avoiding discussion of the communications trainline because it will not be a requirement to connect it due to the position of the Amtrak cars within the consist that is necessitated by other constraints.

Special Hardware Required

From the standpoint of basic electricity, none of the differences mentioned above is difficult to resolve. The ground and secondary continuity detection circuit problem can be solved by the use of a special set of adapter jumpers that feature Control Pin 2 on one end wired to Control Pin 3 on the other end (and vice-versa, see Figure 2). It is possible that a pair of extension jumpers may be needed anyway to adjust for the differing locations of the trainline receptacles on VIA and Amtrak-compatible cars so they may as well also be used to accomplish ground pin switching too. Even if the extra length is not needed to allow plugging in, the same extension jumpers can be used solely to accomplish Control Pin swapping.

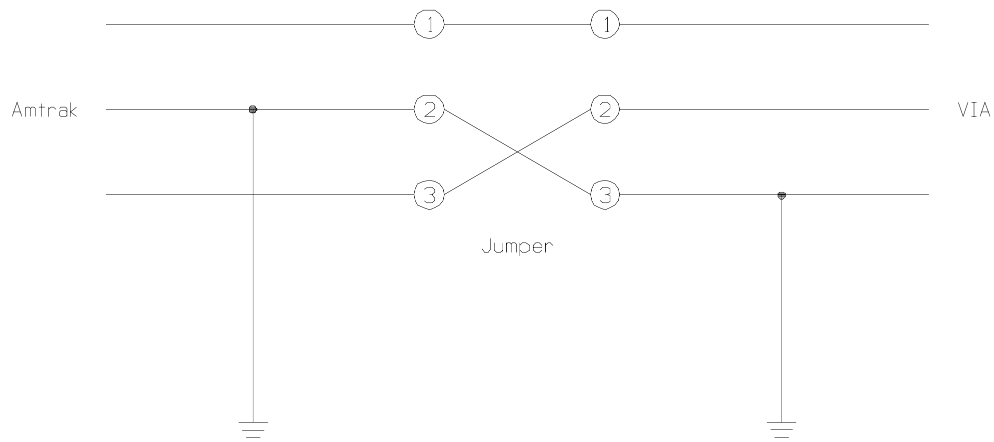

Figure 2: Amtrak/VIA Rail HEP Adapter

Only one pair of these special jumpers would be required between the last VIA car and the first Amtrak-compatible car in the consist or when an Amtrak car or cars are plugged into the VIA wayside power. All of the other Amtrak-compatible cars in the block should be plugged into one another in the usual manner (note that **no** short-looping is permissable).

A set of connectors (male/female) and a suitable length of wire to join them into a jumper (that can be easily assembled) may yield a jumper that is too long when it is inserted between the VIA and Amtrak-compatible cars. If this is the case, either some kind of jumper retractor that will allow the cars to negotiate curves properly while keeping the jumpers off of the track will need to be employed or some method of adjusting the jumper length will have to be used (e.g. the simple knot in the cables is seen in use fairly often, although this does raise the question of inductive heating of the cables).

A number of people who have been to Canada have used a standard Superliner extension cable to fabricate a VIA HEP adapter cable. This cable is fairly short in length so that it does not introduce too much extra wire but it is long enough to allow the wire swapping work to be easily performed. After you make up this cable, it should be clearly labeled to indicate its function and possibly painted a different color as well.

Note that some people advocate the use of an adapter cable that has the wire leading from Control Pin 2 cut and taped back. While this may give the appearance of working fine it is not really doing so. Cutting this wire disables the secondary continuity detection circuit. Furthermore, the ground fault detection circuit is rendered useless on the Amtrak-compatible cars because the circuit that VIA Rail is using for this function is connected to air. So, although this technique will work in a pinch, I do not recommend the use of it. Much better to have a proper set of VIA HEP adapter cables on board your car.

The split trainline problem (when VIA is supplying the train from two locomotives) can be solved by always running the Amtrak-compatible car or cars at the trailing end of the consist. If only one locomotive is supplying power to the train, placement of the Amtrak car or cars is not important (although you will now need a full compliment of 8 VIA HEP adapter cables, not just two) but to make sure that no guesswork is involved, the Amtrak-compatible cars should always be marshalled at the end of the train as a matter of course.

Steps to Follow in Trainlining Amtrak PVs

The Amtrak car or cars should be plugged into only one side (right) of the VIA consist using a pair of VIA HEP adapter cables in between the last VIA car and first Amtrak-compatible car. If the first Amtrak-compatible car is plugged into both sides of the VIA car ahead of it and two locomotives are supplying power to the train, dire consequences (or at least a fireworks display) are likely to result.

It is desirable to add the load to the power source in an even manner since VIA cars alternate drawing power from the left or right portions of the trainline to spread the load out. To do this, always plug the Amtrak-compatible car or cars into the right hand plugs, looking at the last VIA car (see Figure 3). Short-loop the unplugged (left) side of the two cars.

Figure 3: Plugging Amtrak-compatible Cars into a VIA Rail Consist

Plug additional Amtrak-compatible cars into the first one in the normal manner. Note that all intermediate plugs in a block of Amtrak cars **must** be plugged in for VIA's secondary continuity detection circuit to work. Also note that the trainline complete interlock on the side, that wasn't plugged into the VIA consist, of all the Amtrak cars is disabled and it is possible to remove live plugs without the trainline power being disconnected by the safety interlock. Exercise the same amount of caution that you would around any short-looped car.

Double back the left and right sides of the trainline on the last Amtrak-compatible car in the normal fashion. This will allow the VIA trainline complete circuit to protect at least one side of the Amtrak cars.

Using this scheme, it is possible to add one or two Amtrak cars to a VIA consist with impunity and to cause no more overbalance in the current drain on the power sources than is normally expected by VIA. It is up to VIA to determine how many more cars they will permit on the train, since each additional one overbalances one power source by that much more (on trains with only a single power source, the point is moot). Perhaps one more, for a total of 3, is a good rule of thumb but it need not be cast in concrete.

Finally, when plugging in the trainline, it will be necessary to physically cross the trainline cables over one another because VIA has their receptacles and plugs positioned in opposite locations to where Amtrak places their's (i.e. if the plug/receptacle locations are numbered 1, 2, 3, 4 looking at the end of the car, VIA will have a fixed jumper at locations 2 and 4 and a receptacle at locations 1 and 3 while Amtrak will have a fixed jumper at locations 1 and 3 and a receptacle at locations 2 and 4). Crossing the cables over will take care of this little detail.

Last but not least, as mentioned before, the communications trainline is simply left disconnected. Due to the trailing position of the Amtrak-compatible cars, there is no need to propagate the communications trainline through the remainder of the cars (on most PVs, it is essentially pass-through anyway).