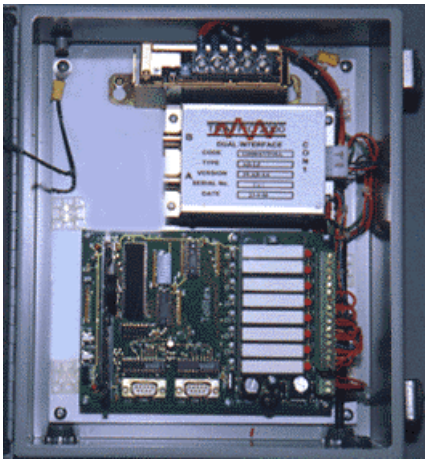
Tolltex

General Applications for Tolltex RoadMate Embedded Controller



Tolltex designed the RoadMate as a general-purpose, sub-system controller that can be adapted to various uses in both toll collection systems or Intelligent Traffic Management Systems (ITS). The RoadMate is best suited to deal with low-level processing of digital input and output signals. The RoadMate is intended to offload processing from the host computer by dealing with low-level digital (discrete) signals and reporting results to the host via serial communications.

Toll Applications:

Vehicle Classification - One important aspect of controlling operations in a toll lane is classifying vehicles. The RoadMate is well suited to perform this task and report results to a host computer in a single message sent via serial communications. Vehicle classification varies from one toll authority to another. Typically, the number of axles is the basis of classifying a vehicle. Other factors are the presence of dual tires or vehicle height. The RoadMate is designed to send a vehicle classification message based upon customer needs.

For accurate vehicle classification, it is necessary to first accurately separate vehicles. Often, loop detectors serve as vehicle separators. However, the basic design of a loop detector limits the accuracy needed in today's toll collection systems. The most basic shortcoming of a loop detector is its inability to consistently report vehicle separation. In bumper-to-bumper traffic, signals from the detector may stay ON for more than one vehicle. This results in the loss of vehicle separation. In this case, transaction data for multiple vehicles is reported for only one vehicle.

Another loop detector shortcoming is its inability to detect aluminum. The case of an aluminum frame on a tractor-trailer results in signal "drop out". In this case, the loop detector reports multiple signals for a single vehicle. Loop detectors have a similar problem detecting vehicles towing trailers. Again, the vehicle separation is affected by "drop out" of the loop detector signal, resulting in a loss of overall system accuracy.

For the above reasons, other methods of separating vehicles are preferred. Light curtains produce excellent separation although their cost can be high. Thru-beam sensors or ultra sonic sensors

have been used but they tend to miss trailer hitches as well as other "breaks" in a single vehicle. For example, depending upon the distance above the surface of a lane at which a single thru-beam sensor is placed, it is possible for the beam to "shoot" between the cab portion of a truck and the body. This would trigger a signal drop out and loss of accurate vehicle separation.

Overhead laser beam sensors, often called "vehicle profilers", are another accurate device which may be used for vehicle separation. In addition to vehicle separation, some of these sensors have the ability to classify a vehicle according to the profile of the scanned vehicle. Video cameras and digital image processing are also being used for vehicle separation although system requirements and cost may preclude their use.

Depending upon the budget, the RoadMate can use the signal from a loop detector, light curtain, thru-beam sensor or ultra-sonic sensor. Furthermore, if the laser scanner or the video camera subsystem produces a digital or serial signal corresponding to the presence or absence of a vehicle, the RoadMate can process that signal as well.

Signal Conditioning - Some devices such as mechanical treadle strips are prone to signal "bounce" as the device output is activated and deactivated. This bounce is due to the mechanical nature of the electrical contact. The RoadMate stabilizes these bouncing signals using debounce logic. The length of time in which a signal must be on before it is considered stable is called the "de-bounce period". Once a signal is stabilized with this debounce logic, the RoadMate processes it. The de-bounce period in the RoadMate is software configurable both at system start up and "on the fly". Typically, a 5ms to 10ms de-bounce period is sufficient to filter out unwanted signal "spikes". However, if a sensor has been in use for a while, it may be necessary to increase the de-bounce period.

Axle Counting - The normal method of classifying vehicles includes at a minimum a count of axles for each vehicle. The RoadMate can interface with any of the two-contact or four-contact treadles currently available. Each treadle strip becomes a digital input signal to the RoadMate. As a vehicle moves across the treadle strips, the RoadMate de-bounces each signal and counts the activation on the corresponding strip. Consider a two-strip treadle and a two-axle vehicle moving forward through the lane. In this example, the first strip will be referred to as the "A" strip and the second strip as the "B" strip. To determine an axle, there must be activation on both the A and B strips. If there is only activation of one strip, it typically means that the vehicle has either stopped between the two strips or has reversed direction. At this point, there is no count of an axle. When both strips are activated, the RoadMate records the event as an axle and adds "1" to the axle count for that vehicle. Also, since the order of activation was A followed by B, the RoadMate is able to determine vehicle direction for that axle.

If that same vehicle were to "back-up" after the front wheels had crossed both the A and B strips, the events processed by the RoadMate would be an activation of B followed by A. Axle direction

would be reverse and the RoadMate would subtract "1" from the net axle count. The resulting "rollback" would adjust the net axle count to zero. As the vehicle moved forward again and crossed the treadle strips, the A followed by B events would result in the axle being counted. Once the vehicle has passed the vehicle separator, the net axle data is sent to a host computer via a serial port message.

The following is an example the signal events corresponding to a two-axle vehicle crossing all strips in the forward direction and completely exiting the lane:

Strip A ON - Front Axle

Strip B ON - Front Axle

Strip A OFF - Front Axle

Strip B OFF - Front Axle

Strip A ON - Rear Axle

Strip B ON - Rear Axle

Strip A OFF - Rear Axle

Strip B OFF - Rear Axle

For the above signals, the RoadMate would report that a two-axle vehicle moving in a forward direction.

If the treadle strips were placed further apart, the above example might occur as follows:

Strip A ON - Front Axle

Strip A OFF - Front Axle

Strip B ON - Front Axle

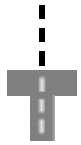
Strip B OFF - Front Axle

Strip A ON - Rear Axle

Strip A OFF - Rear Axle

Strip B ON - Rear Axle

Strip B OFF - Rear Axle



Again, the RoadMate would report a two-axle vehicle moving in a forward direction.

Framing Transactions – The RoadMate processes all signal data and associates the axle count with the vehicle according to the signal generated by the vehicle separator. Placement of the vehicle separator in the lane determines the order of signals processed. Vehicle direction also determines the ordering of signals. Basically, when the vehicle separator turns ON, any treadle activity is accumulated until the vehicle separator signal turns OFF again which signals that the vehicle has exited the lane.

Addition of the vehicle separator to one of the above examples results in the following events:

Vehicle OFF - No vehicle in lane, vehicle separator is OFF

Vehicle ON - Vehicle enters the area near the treadle strips, signal turns ON

Strip A ON - Front Axle

Strip B ON - Front Axle

Strip A OFF - Front Axle

Strip B OFF - Front Axle

Strip A ON - Rear Axle

Strip B ON - Rear Axle

Strip A OFF - Rear Axle

Strip B OFF - Rear Axle

Vehicle OFF - Vehicle clears treadles

In the above example, the RoadMate sends the vehicle classification message after the vehicle clears the treadles which is signaled by the vehicle separator signal changing state from ON to OFF. This is also the point in which the RoadMate clears its axle counter in preparation of processing the next vehicle.

Reverse Direction – Vehicles can travel through a lane in a reverse direction. Although this is not the normal mode of operation, it can occur and the RoadMate can deal with the condition. Revising the previous example to a two-axle vehicle entering the lane from the opposite side, and traveling completely through the lane, would produce the following signal events:

Vehicle OFF - No part of the vehicle has reached the vehicle separator

Strip B ON - Front axle

Strip A ON - Front axle

Vehicle ON - Front of vehicle reaches vehicle separator, signal ON

Strip B OFF - Front axle

Strip A OFF - Front axle

Strip A ON - Rear Axle

Strip B ON - Rear Axle

Strip A OFF - Rear Axle

Strip B OFF - Rear Axle

Vehicle OFF - Vehicle has cleared the separator, signal turns OFF

In the above example, the RoadMate correctly reports a two-axle vehicle traveling through the lane in a reverse direction. Counting of treadle activations begins as the events occur even though the activation of the vehicle separator occurs between the activation of treadle strips B and A instead of before the first axle reaches the A strip as it does when a vehicle passes in the forward direction. Again, the transaction is sent after the vehicle separator changes state back to OFF at which time the axle counters are cleared in preparation of processing the next vehicle.

Dual Tire Detection – There are treadles on the market that report the presence of a dual tires on a vehicle. The RoadMate is capable of interfacing with such devices. In this configuration, the vehicle classification message sent by the RoadMate includes a count of dual tires in addition to the number of axles. A variation of this reporting can be the total number of tires on the vehicle rather than simply a count of the number of dual tires. The data sent is determined by the classification needs of the client.

A digital input signal from the dual tire treadle is processed by the RoadMate. The signal typically arrives as the dual tire passes over two treadle strips that have been installed at an angle to the curb. This event causes a tire count to be incremented. If the vehicle backs up, both the axle count and the dual tire count are decremented. A running total of counts are maintained until the vehicle clears the lane and the vehicle separator changes its state back to OFF. The following shows the signals of a three-axle vehicle with 2 sets of dual tires passing through the lane in a forward direction:

Vehicle OFF - No vehicle in lane, vehicle separator is OFF

Dual Tire OFF - No vehicle in lane, dual tire signal is OFF

Vehicle ON - Vehicle enters the area near the treadle strips, signal turns ON

Strip A ON - Front Axle

Strip B ON - Front Axle

Strip A OFF - Front Axle

Strip B OFF - Front Axle

Strip A ON - 2nd Axle with Dual Tires

Strip B ON - 2nd Axle with Dual Tires

Dual Tire ON - 1st set of dual tires, signal set ON

Strip A OFF - 2nd Axle with Dual Tires

Strip B OFF - 2nd Axle with Dual Tires

Dual Tire OFF - 1st set of dual tires detected, signal set OFF

Strip A ON - 3rd Axle with Dual Tires

Strip B ON - 3rd Axle with Dual Tires

Dual Tire ON - 2nd set of dual tires, signal set ON

Strip A OFF - 3rd Axle with Dual Tires

Strip B OFF - 3rd Axle with Dual Tires

Dual Tire OFF - 2nd set of dual tires detected, signal set OFF

Vehicle OFF - Vehicle clears treadles

Height Detection – If vehicle classification requires some level of vehicle height reporting, this requirement can be met by use of one or more sets of thru-beam sensors installed on each side of the lane. As tall vehicles pass through the beams, the signal is processed by the RoadMate and factored into the vehicle classification message sent for that vehicle.

Since overhead thru-beam sensors are prone to becoming dirty due to exhaust fumes and/or dirt,

the RoadMate includes logic to monitor the signal and report unusual conditions. The basis of these unusual occurrences can be established by the client. For example, if ten vehicles in a row all have the height detector ON, it might be inferred that the sensor is blocked due to dirt. In this case, the RoadMate will send a diagnostic message to alert of the condition.

Summary of Toll Collection Applications – This section has described some of the possible application uses of the RoadMate in a typical toll collection system. From experience, we know that each toll operation has unique vehicle classification requirements. For that reason, the RoadMate is designed to be customized to meet the operational needs and specific vehicle classification requirements of various toll facilities.

ITS Applications

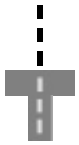
Modern ITS applications are sophisticated wide-area management and control operations based on sensor data. This sensor data originates in the field, typically along highways. The RoadMate can function as a component of an ITS project in which it would monitor in-pavement sensors and report counts of vehicles to a central ITS host computer.

Vehicle Counting - The RoadMate will support any type of counting sensor that can output a digital signal. A typical device is a loop detector that reports vehicle counts. Piezo-strip sensors are also used in ITS applications to count axles.

Two serial communication ports on the RoadMate are available for host communications. These ports can be hardwired or connected via modem to report vehicle data to a central ITS host computer. The serial interface will allow the host to request data in various formats. For example, detail mode can be invoked to send a short transaction each time the loop detector is activated. The transaction can include a date/time stamp or the host could add the timestamp when the message is received.

Various types of summary modes of reporting can be configured. For example, total activations of the loop over any given time period(s) will send the host a message containing summary count information. Combinations of summary periods can be set to record, count, and send messages summarizing counts over 15 minute, 30 minute, 1 hour, or any other predetermined period of time. These summary periods can be configured by the ITS host sending configuration messages to the RoadMate. This results in the RoadMate producing various types of detail as well as summary level reporting without the need to make any programming changes.

If it is necessary to reset the RoadMate counters to zero, a reset message can be sent by the ITS host. Upon receipt of the message, the counters will be reset.



Vehicle Speed - A single RoadMate can monitor up to eight (8) digital signals. Combinations of two loops in a lane can also be used to determine the approximate speed of vehicles traveling over a roadway. Therefore, a single RoadMate could be used to monitor 4 lanes of a highway, each equipped with two loops to determine a traffic count and approximate vehicle speed.

The RoadMate can also be used to report exceptions or unusual occurrences such as threshold levels. In this mode, a threshold level can be determined to be any period of time in which certain counts are reached. For example, a threshold could be set according to the number of vehicles over a given period of time which correspond to bumper-to-bumper traffic. In this mode, the RoadMate could be set not to report anything unless the threshold is reached, and when it clears. Or, the RoadMate could continue to send either detail or summary records throughout the period with the special threshold messages mixed in with the normal summary messages.

Year 2000 - The RoadMate hardware and software are year 2000 compliant and requires any date/time commands sent to it to be in a year 2000 format. The RoadMate includes a real time clock which is set from the ITS host. The date/time is normally sent from the host during initialization. Also, the RoadMate will accept an initialization message to be sent by the ITS host at any time. Upon receipt of the message, the RoadMate will update its configuration and continue processing. This includes the date/time setting.

ITS Control – Each of the eight (8) digital input/output channels on the RoadMate can be configured as either input or output. This allows the RoadMate to both monitor and control devices. For example, in combination with the "threshold" feature described above, the RoadMate could turn on/off a warning light or some other visual indicator. This would allow motorists to be warned of a traffic jam ahead.

If the ITS enterprise includes predetermined indicators, the ITS host could send messages to the RoadMate via the serial port causing the RoadMate to turn on/off the appropriate indicator. If the ITS enterprise is designed using variable message signs which are operated via serial link, then the RoadMate may actively change the message signs. This allows one data line from the host to both gather data and display data.

Summary of ITS Applications – This section has described some of the possible uses of the RoadMate as part of the many sophisticated ITS projects that are being planned and implemented on a world-wide basis. Although the RoadMate was not designed to be a full-scale traffic controller, the flexible nature of the product can help support the low-level monitoring and control requirements used by nearly every ITS project.