Traffic light control system

A traffic light control system comprising a plurality of controllers each for controlling a traffic light signal unit, one of the controllers being a master controller and the other or others slave controllers, wherein the master controller is operable to transmit to each slave controller the required signal state of its associated signal unit and each slave controller is operable to compare the actual signal state of its signal unit with its required state as defined by the last required state received from the master controller and activate a failure condition procedure in the event of a conflict between the actual and the required signal states.

![Diagram of traffic light control system](image-url)
Description

[0001] The present invention relates to traffic light control systems, and more particularly to systems for controlling the operation of signal units in a set of traffic lights.

[0002] An important requirement in relation to traffic lights is ensuring the safety of road users in the event of any technical failures in the operation of the traffic lights. Thus, for example, in the event of the failure of the bulb illuminating the red light, a road user may be under the misapprehension that it is safe when in fact traffic from his direction should be halted, and conflicting traffic from another direction has been signalled that it is safe. Accordingly it is necessary that the signal state of all the signal units in a set of traffic lights should be continuously monitored, in order that a failure condition procedure can be promptly initiated, usually by switching all the signal units to a red signal condition.

[0003] Having regard to the distance in which a motor vehicle can travel in just a very short period of time, and the relative lack of awareness of at least some road users to the possible risks involved in traffic light failure situations, it is important that any control system should be able to recognise a failure condition as quickly as possible. In a conventional set of traffic lights with four signal units controlling a four-way junction, one of the signal units would normally be provided with a master controller, with the other three signal units each being provided with a respective slave controller. The master controller successively interrogates each of the slave controllers in turn to determine its current state. This includes, which signal lamp is illuminated at the time, but usually also other features which may be of interest such as, for example, the charge condition of a battery used to power the signal unit lights. The master controller waits for the response from the interrogated slave controller before proceeding onto the next one.

[0004] Because conventional arrangement successively interrogate the units, in the event that a failure condition arises at a given signal unit immediately after it has been interrogated, this will not be detected until a whole interrogation cycle has been completed with all the other signal units being interrogated before said given signal unit is interrogated again. Even with modern electronic hardware and software, such an interrogation cycle will generally take a minimum of one second to complete, thereby resulting in significant delay before a failure condition procedure can begin to be implemented. It is, however, desirable that any critical failure condition should be detected within a significantly shorter period of time, desirably within 500 ms.

[0005] With ever increasing traffic flows and traffic congestion, there is moreover, a need for more intelligent traffic flow management, which is responsive to actual traffic flows at the time. Also there is increasing pressure on users of temporary traffic light (TTL) systems, to manage their operations so as to minimize disruption. This is often in the form of restricted hours and times of day permitted for operations.

[0006] According to one aspect of the present invention, there is provided a traffic light control system comprising a plurality of controllers each for controlling a traffic light signal unit, one of the controllers being a master controller and the other or others slave controllers, wherein the master controller is operable to transmit to each slave controller the required signal state of its associated signal unit and each slave controller is operable to compare the actual signal state of its signal unit with its required state as defined by the last required state received from the master controller and activate a failure condition procedure in the event of a conflict between the actual and the required signal states.

[0007] By allowing the slave controllers themselves to initiate a failure condition procedure, this removes the requirement to wait for such a failure condition to be detected by the master controller during successive interrogation of the slave controllers. Hence, it is possible to achieve a very fast response time to signal failure conditions. For example, regular monitoring of their respective signal units by the slave controllers can typically be completed within about 1 to 5ms, so that detection of and response to a critical error alert can be completed within as little as a maximum "latency" period of about 25ms or less. This rapid response time is achieved without imposing any additional signal traffic load on the communication system between the various controllers. This helps maximize the capacity of the system for incorporating various additional, intelligent traffic flow management, features.

[0008] In use, each slave controller is operable to operate and monitor its associated signal unit and monitor any respective detector unit provided.

[0009] The master controller is operable to successively interrogate each of the slave controllers and receive a status and/or traffic reports therefrom.

[0010] The master controller is operable to transmit signal unit switching commands as and when required, for example in response to a traffic report from one or more of the slave controllers.

[0011] Preferably each of the slave controllers is operable to monitor all signal change system broadcasts to all slave control modules, and maintain a system status record indicating the current signal status of all signal units, whereby a given slave controller can compare the signal status of the signal unit to which it is connected, with the signal status of other signal units and check for any conflict with the signal status of other signal units. Thus, for example, if a given slave controller receives a switching command to switch its signal unit from red to green, and the slave controller is aware that another signal unit is still at green, then it can immediately enter a fault condition procedure.

[0012] The required signal state of a given signal unit may typically be red or green. Where an amber signal is also included, one or more further states such as amber and red + amber may be available. The signal state de-
Pend on where in its operating sequence cycle the traffic light set is taking into account any available override conditions, for example, when a particular approach direction is given priority following detection of an approaching vehicle etc. Apart from faults such as failure of a lamp illuminating a particular signal in a signal unit, other dangerous faults which may occur include a particular signal, especially a green signal sticking in an illuminated state, so that when another signal unit also switches to a green signal state, this can result in multiple green signal states in conflict with one another, or a critically low battery power level.

[0013] Various failure condition procedures may be used in accordance with the present invention. One preferred procedure comprises switching the affected signal unit to red. Another possible procedure involves switching off of the signal unit. In this case the individual controller would then desirably attempt to switch the signal unit back on at red, and resume monitoring of the signal state of the signal unit. In the event that a serious failure condition is still found, for example if red and green are both on in the signal unit, then the signal unit is switched off.

[0014] At the next interrogation of the slave controller by the master controller, the slave controller reports the incorrect signal state and fault condition it has detected. Advantageously, the master control module can then initiate a system wide failure condition procedure. One preferred procedure comprises switching all the signal units to red. Another possible procedure involves switching all of the signal units off. Conveniently the procedure may also include sending a communication signal e.g. a text message, to a central, operator-supervised, control, when a suitable communication channel, for example a cell-phone, is available.

[0015] The present invention can be used with either fixed traffic light sets or temporary traffic lights sets, such as those used at the site of road works and the like. In the case of temporary traffic light control systems, the user or owner of these may at any given time hold a more or less large inventory of signal units, which may be required to be deployed in various different combinations, for example 2-phase, 3-phase or 4-phase operation, according to the number of different traffic flow streams to be controlled at the site, from week to week, or even day to day. Therefore, it is desirable that individual signal units should be as flexible as possible in their use and application. Hence, although a given control system would operate with only one master controller, each controller may be provided with both master and slave controller capabilities, and may include means for switching between these, so that any signal unit may readily be reconfigured for master or slave operation.

[0016] The master and/or the slave controllers may be implemented via discrete dedicated processors or as discrete software modules operated on a single processor. Preferably, the master and slave controllers within an individual unit inter-communicate only via an internal communications bus, conveniently RS485 type, to which the inter-unit controller communications system e.g. wireless controller for a wireless modem, or wired network, conveniently RS485 type, is coupled. This helps ensure that the slave controllers in all different units receive the same information.

[0017] Each slave controller may comprise a light supervisor responsible for monitoring the status of the signal head of a signal unit, and a light controller responsible for control of the respective signal head. Each slave controller is also responsible for communications between its associated signal unit and other signal units, and in particular, with the master controller. The light supervisor and light controller may be implemented as separate software modules operating in one processor, or within separate microprocessors. This provides a further level of safety insofar as if one were to fail the other could still be effective in entering a suitable fault condition procedure.

[0018] The light controller functions comprise switching power on and off to individual light units, e.g. red, green, of the signal unit. The light supervisor functions comprise monitoring which light unit(s) is (are) on at a given time. Advantageously, the light supervisor functions may additionally comprise one or more of: monitoring the light intensity of a given light unit, monitoring the ambient light intensity, and comparing the relative light intensities.

[0019] The light controller may provide a master control for the power supply to the light units. With the light supervisor and slave light controller implemented in separate processors, then an additional level of safety could also be provided in this case, by the slave light supervisor also providing a master control "power enable" for the power supply to the light units.

[0020] A particular benefit of the present invention is the increased signals traffic capacity in the communication channel(s) between the various controllers. This allows for expansion of the traffic light control system with various additional units that can be used to improve one or more of traffic safety, traffic flow capacity of the controlled junction or site, communication with the road user, and reduced traffic delays.

[0021] Various detectors, typically radar detectors, may be used for sensing one or more of traffic speed, traffic flow rate (number of vehicles passing a given point), length of stationary traffic queue, signal status of a separate upstream and/or downstream traffic light control system, etc. Sensed conditions may be communicated to the master controller. Suitable detectors are known in the art and available commercially.

[0022] The master controller may be coupled to various other types of signalling units for communicating with road users, such as displays which can be activated to display various types of information that may be helpful to road users such as: an applicable speed limit and/or the actual speed of a vehicle passing a suitable detector, an estimated waiting time, warning of a fault condition in the control system, etc. Such additional units may readily
be connected to the control system communications channels in the same way as the controllers.

[0023] Where several detector units and/or display units are coupled to the control system, then in conventional systems the time required for a complete interrogation cycle could extend to well over 500ms. With the present invention however, a fast reaction to a fault condition, typically within 25 ms, can be achieved by means of the build-in ability of the slave control module to monitor compliance of the signal unit with its required status and to initiate a fault condition procedure in the event of any conflicts, independently of any monitoring of the system at the master control module.

[0024] The interrogation protocol used by the master controller may be substantially the same as with a conventional monitoring system. Typical interrogation protocols include any required combination or sub-combination of status elements such as: lamp failure, battery charge level, other power supply level (e.g. from a generator or a mains supply), and various non-system critical items such as “radar demands” i.e. detection of an approaching vehicle by a vehicle detection radar device provided at a signal unit associated with the respective slave controller, ambient light intensity, etc. The interrogation protocol may include lamp signal status monitoring, including one or more of: signal state i.e. which colour lamp (s) is (are) switched on, the intensity of the light from the lamp(s) switched on, the intensity of the lamp light relative to the ambient light intensity, etc.

[0025] The controllers may be provided with any convenient form of user interface, including “hard” interfaces such as switches (including rotary switches) or “soft” interfaces such as touch screens, for selecting master control module status (active or inactive), initializing the system at the master controller (with the active master control module) for registration of all the individual slave control modules of all the signal units, and any other detector and/or signalling units in the control system, and various control parameters such as type of phase operation required (typically 2, 3 or 4 - phase), timing (e.g. minimum and/or maximum duration of each phase), and “all at red” timings.

[0026] The master controller may be provided with at least one communication channel for communicating with each of the slave controllers.

[0027] According to another aspect of the invention, there is provided a method for controlling a traffic light control system having a plurality of controllers each for controlling a traffic light signal unit, one of the controllers being a master controller and the other(s) being slave controllers, the method comprising transmitting from the master controller to each slave controller a required signal state for its associated signal unit; and implementing at each slave controller the required signal state, the method being characterised by the slave controller: comparing the actual signal state of its signal unit with its required state as defined by the last required state received from the master controller and activating a failure condition procedure in the event of a conflict between the actual and the required signal states.

[0028] Further preferred features and advantages of the present invention will appear from the following detailed description given by way of example of some preferred embodiments described with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram of a 4-phase traffic light control system;
Figure 2 is a more detailed schematic diagram of an individual controller and signal unit;
Figure 3 is a detailed schematic diagram of a signal head controller for a signal unit;
Figure 4 is a schematic timing chart for the master controller signal transmissions in a control system with four signal units; and
Figure 5 is a schematic diagram of the power management and control and status signals associated with the signal head controller, light controller and light supervisor.

[0029] Figure 1 shows a 4-phase traffic light control system of the invention 1 in use in a set of traffic lights 2 for a 4-way junction, and comprising four signal units 3a-3d, each provided with a respective controller 4a-4d. As explained further below, the controllers 4a-4d are essentially identical. Each one is switchable to either master controller or slave controller mode operation. This is done when the control system 1 is initially set up. In the present case the first controller 4a, is designated to be the master controller MC, and the other three slave controllers SC 4b-4d. Each controller 3a-3d is provided with a wireless modem WM 5 for sending and receiving signal transmissions 6 from one or more other controller as appropriate. Each signal unit 3a-3d also is provided with a radar detector D 7, and a signal head control unit SHC 8.

[0030] Figure 2 shows a controller 4. This comprises a light controller LC 9, light supervisor LS 10, and wireless controller WC 11 which has a RS232 connection 12 to the wireless modem 5. The radar detector D 7 is connected to the light controller 9. The light controller 9 also has a master control module 13 and a slave control module 14. Normally only the slave control module 14 is active, but in the case of the master controller 4a (see Figure 1), the master control module 13 is also activated at initial set up by a master-slave select switch 15.

[0031] The active master control module 13 is connected to the slave control module 14 and light supervisor 10 of the master controller 4a, and the wireless controller 11, via an RS485 bus 16. Where wireless communication is practical, the master control module 13 would normally communicate with the slave control modules 14 of the light controllers 9 and the light supervisors 10 of the slave controllers 4b-4d via the wireless controllers 11 and wireless modems 5. Where this is not practical, then communication may be effected instead via RS485 cabling 17 interconnecting the RS485 buses 16 of all the controllers.
and slaves 4b. If desired it would also be possible to have certain controllers 4 interconnected wirelessly and other by RS485 cabling. Thus the master control module 13 communicates in a generally similar manner with the slave control modules 14 of all the controllers both master 4a and slaves 4b-4d via the RS485 bus. Any additional optional elements such as a remote control interface 18, PC interface 19, display device 20 for e.g. one or more of controller status information, diagnostics information, operation information e.g. running timer of current signal unit phase, error codes, etc, and human interface device 21 such as a keypad, rotary and/or other kinds of switches, would also be connected to the RS485 bus.

The signal head control module 8a in the signal unit phase, error codes, etc, and human interface device could be combined in a touch screen or the like. Naturally a display device and human interface device could be combined in a touch screen or the like. On detecting a vehicle, the radar detector D 7 positioned on top of each signal unit 3, generates an output signal, which is connected directly to an input port on the light controller 9. This signal causes the light controller 9 to recognise the presence of a vehicle. This information may be used by the master control module 13 to influence the switching of the green phases on the signal units 3.

The signal head controller 8 is comprised of three control modules - one for each of the red, amber and green signal lights 26. Figure 3 shows schematically the principal parts of one such signal head control module 8a, and its interfacing with the signal unit 3 and master/slab controller 4. The signal head control module 8a has a first microcontroller MC1 PC 22 which provides a pulsing control of the duration of the power supplied from the power supply BV 23 (see also further description below with reference to Figure 5) to an LED drive circuit LED DC 24 connected to the LED array 25 of a respective signal light 26 of the signal unit 3. Using such a pulsed mode of operation, it is possible to considerably overdrive an LED, compared to it being continuously on, in order to maximise the light output. In order to prevent overheating of the LEDs, the duty cycle is kept low. The first microcontroller also measures the voltage from the battery in order to determine the optimum mark/space ratio to modulate the LED array. As the battery slowly discharges the voltage measured by the microcontroller will fall. The light output level depends on the current flowing through the LEDs. Any reduction in supply voltage will reduce this current, and consequently the light intensity from the LEDs. Therefore as the battery voltage falls, the microcontroller increases the mark, or on period, to compensate.

The first microcontroller 22 also monitors the voltage output from an ambient light sensor 27, which is incorporated into the case of the signal head 3. This is used to detect when the ambient light has reduced sufficiently so that the LED arrays may be driven in ‘dimmed’ mode. In this mode, the light intensity may be reduced to 20 - 25% of the light intensity required in daylight conditions. The dimming is achieved by reducing the mark period.

The signal head control module 8a in the signal head controller 8 also has a second microcontroller MC2 IP 28 which is responsible for sending signal head status reports to the light supervisor 10 of the controller 4. In addition the second microcontroller 28 monitors the light intensity measured by a respective photo-sensor 29 placed just off-centre within the LED array 25 of each signal light 26 and positioned to face slightly down towards the LEDs thereof. In this position the photo-sensor 29 is substantially unaffected by incident external light. This photo-sensor 29 provides a voltage signal, which is directly proportional to the light intensity generated by that array. The second microcontroller 28 also monitors the output from the ambient light sensor 27. Using the voltage levels from these two inputs the microcontroller is able to signal via a status line that: the array is off; or the array is on with sufficient intensity for the ambient light level; or the array is on with just acceptable intensity for the ambient light level but has reduced output from normal and maintenance may be required; or the array is on with unacceptable intensity for the ambient light level and requires maintenance.

Each of the second MC2 microcontrollers 28 (one each for red, amber and green) uses a single status line to signal, by means of pulse width modulation, to its light supervisor 10. Conditions which require maintenance or repair can be reported by using the diagnostic LCD display 20 on the controller 4.

In use of the above described system, the master-slab select switch 15 on the master controller 4a having been set to master mode operation for that controller only, the user then selects the number of phases (up to 4 in the present case), and the junction red and green times via the human interface device 21 - conveniently rotary switches on the master front panel. At power on, the master controller 4a attempts to locate the number of slave controllers 4b-4d indicated by the phase number selected. This process is known as system registration. Following successful registration the master control module 13 will manage the sequencing of the traffic light signal units 3a-3d according to the user selected operating mode and the red & green times for each part of the junction controlled by the system 1. The master control module regularly broadcasts the required state of all signal units 3a-3d and in turn interrogates all signal units 3a-3d including its own slave control module 14. Upon receipt of the broadcast, the individual light controllers 9 apply their instructed light state to the respective first microcontrollers 22 that enable the red, amber and green light drivers 24.

Figure 5 shows schematically various control connections between the light controller 9, light supervisor 10, and signal head controller 8. A light power enable output 30 from the light controller 9 and a separate light power enable output 31 from the light supervisor 10 are used to enable respective ones of two relays R1, R2 32, 33. The relays 32, 33 are wired in series and when enabled arc used to connect power supply BV 23 to the control modules 8a etc, in the signal head controller 8.
either power enable signal 30 or 31 is off, then the signal head controller 8 is disconnected from the power feed and all the lights are switched off. If the applied light state is invalid, e.g. Amber and Green together, then the light supervisor 10 turns its light power enable output 31 off. This removes the power feed coming from the power supply 23 via the relays 32, 33, to the signal head controller 8, and all the lights are switched off. The status of the respective red, amber and green light LED arrays 25 is fed back to the light supervisor 10 via the photosensor 29, and the second microcontroller 28 associated with each signal light 26. This is the state the light supervisor 10 reports when it is interrogated by the master control module 13. Figure 3 also shows the light driver enable 35 going from the light controller 9 to the first microcontroller 22. This enable signal 35 causes the first microcontroller 22 to start the pulsing control to the LED drive circuit 24. A light driver enable signal 35 is provided for each of the red, amber and green signal lights, and Figure 3 illustrates the connection for only one of the signal lights. Figure 5 illustrates the 3 light driver enable signals 35 from the light controller 9 to the signal head controller 8.

0040 Upon receipt of the broadcast, the light supervisors 10 compare the instructed signal state with signals from the red, amber and green photo-sensors 29 within the signal head 3. The light state decoded from these signals is the state that the light supervisor 10 reports when it is interrogated. If the light supervisor 10 detects a conflict between the decoded light state and the instructed light state it will turn off its light power enable signal i.e. switch off the power to the signal head 3. The status information from the signal head 3 allows the light supervisor 10 to distinguish between a head 3 not working correctly / not connected / broken wire, light off, light working satisfactorily, and light working satisfactorily but maintenance may be required. This information can then be reported by a diagnostic unit or monitoring unit.

0041 Immediately that an error condition is detected, which has caused power to the signal head 3 to be removed, an attempt is made to restore the power and turn on the red light of the signal unit 3. In the case of a soft or transient error the light controller slave control module 14 will be able to recover to this position. In the case of a hardware error or conflict, e.g. red and green on the same signal head are detected as being on simultaneously, then the power will be removed again from the signal head 3 and a message will be sent to the diagnostic display unit 20. The light controller 9 and light supervisor 10 also receive a synchronization status signal from one another. If either detects loss of synchronization, then their power enable signal is turned off i.e. the respective relay 32, 33 is released causing the signal head power supply 23 to switch off.

0042 In addition to receiving switching signals from the master control module 13 of the master controller 4a, the slave control modules 14 of the various controllers 4a-4d, can also receive status report transmissions from the light supervisors 10 of other controllers 4a-4d, and detect any conflicts such as, for example, when a given controller which has its own signal unit at green, detects that the controller for another signal unit is also green, then it can recognize this as a "conflict" and initiate suitable failure condition procedure. It should be noted that in cases where two traffic flows would be controlled by signal units on the same signal light setting, i.e. red at the same time, and green at the same time, then the two signal units would normally be connected and controlled by a common controller 4.

0043 During normal operation of the control system 1, the master control module 13 continuously monitors the system 1 by transmitting messages, each containing the required system state including the signal status of all the signal units and interrogating individual light controllers 9 (slave control module 14) and light supervisors 10, of each of the controllers 4a-4d, in turn. As shown in Figure 4, each such message transmission from the master control module 13 generally takes about 50 milliseconds, followed by a similar window for receiving the status report reply. If this is in order, then the next slave control module 14 is interrogated etc, so that in a 4-phase system, interrogation of all 4 controllers can be completed within 400 ms, which is well within current limits for the detection of a failure condition at any one of the signal units in a control system. In the case that no reply at all is received from a given unit, then the interrogation transmission for that unit is repeated once, to allow recovery from any momentary glitch. In the event that no reply is received to the second interrogation, then the master control module 13 will initiate a failure condition procedure, for example, the master control module 13 broadcasts a new system state of all reds whilst continuing to query all controllers 4a-4d, in turn. The broadcasting of all the reds system state continues for up to 10 seconds. If during this time communication is re-established for 2 seconds without an error the system will restart the normal required light sequence control.

0044 The controllers 4 communicate by a protocol that defines that information is transferred by messages. There are two different types of messages - internal and system wide, distinguished by the start character of a message. All messages contain a message type and can support a variable number of variable length parameters. All messages contain a checksum and are terminated by a message end character. The message start and end characters are unique and cannot occur within any message. This helps recovery of message synchronisation in the event of broken communication.

0045 Internal messages are restricted to an individual master/slave controller 4a-4d i.e. these messages are not transported between different controllers 4a-4d. Furthermore, the use of internal messages is restricted to immediately after power on and during system registration. System wide messages are used for all broadcast, interrogation and reply messages. To assist with system integrity each master and slave unit is coded with
a unique 16bit serial number. Serial numbers are exchanged only during the initial system registration, when the master control module 13 will disclose its serial number and then expects the controller and supervisor of a selected slave to report back with their own identical serial numbers including its own slave module and supervisor. Thereafter, units are identified in broadcast, interrogation and reply messages by their unique 16-bit serial numbers. This will prevent a slave from responding to more than one master, or a master interpreting a message from a slave that was not registered at power on. Such a situation could occur when there were two or more adjacent wireless networks able to receive one another's wireless transmissions.

Where a remote control unit 36 is to be connected to the remote control interface 18 of a master/slave controller 4a-4d of a system, it is necessary to connect the remote control unit 36 to the master controller 4a for initial system registration. This allows the master controller 4a to log the serial number of the remote control unit 36. The remote control unit 36 can then be disconnected and then be connected to a slave controller 4b-4d. The remote control unit 36 will operate with the master controller 4a from which it receives interrogation and which has already logged its serial number. This means it is possible to register a remote control unit with several masters in different systems at different time but the remote control unit 36 will only control one system 1 at any one time.

In order to allow the traffic light control system to operate as efficiently as possible, additional detector units may be connected to the system so that scheduling decisions can be made which are based upon traffic flow which has not yet reached the traffic light system. These detectors are typically radar detectors. The information from these detectors can be passed to the master controller in two different ways. For example, a number of such detectors can be included into the RS485 and wireless communications system. If in a four-phase system, an additional radar detector were to be provided upstream in each direction, then there would be eight radar detectors in the overall system (4 units on signal heads and 4 in upstream positions). It is important to note that in such a system the time critical nature of the master-slave communications requires absolute priority over non-time critical information provided by any additional radar detectors. However, in normal operation there is sufficient bandwidth in the communications system for the master controller to receive additional information. As the sampling rate of any additional detectors in the system is much slower than the master-slave sampling rate, for example every 5 to 10 seconds, the additional overhead on the communications bandwidth is quite limited. Another approach is to implement an additional communications system, using wireless and/or RS485, which does not involve the master-slave system. Such a system can use a separate communications port on the master controller to interrogate periodically the additional radar units. This then isolates the time critical communications from those which are more infrequent and non-time critical. As before the processing load placed on the master controller to support such activity is relatively small.

Claims

1. A traffic light control system comprising a plurality of controllers each for controlling a traffic light signal unit, one of the controllers being a master controller and the other or others slave controllers, wherein the master controller is operable to transmit to each slave controller the required signal state of its associated signal unit and each slave controller is operable to compare the actual signal state of its signal unit with its required state as defined by the last required state received from the master controller and activate a failure condition procedure in the event of a conflict between the actual and the required signal states.

2. A system as claimed in claim 1 wherein each slave controller is operable to monitor any respective detector unit provided.

3. A system as claimed in claim 1 or claim 2 wherein the master controller is operable to interrogate the or each slave controller and receive a status and/or traffic report therefrom.

4. A system as claimed in any of the preceding claims wherein each slave controller is operable to monitor all signal change system broadcasts to all slave controllers, maintain a system status record indicating the current signal status of all signal units, compare the signal status of the signal unit to which it is connected with the signal status of other signal units, and check for any conflict with the signal status of other signal units.

5. A system as claimed in any of the preceding claims wherein the failure condition procedure comprises switching the affected signal unit to red.

6. A system as claimed in any of claims 1 to 6 wherein the failure condition procedure involves switching off of the signal unit.

7. A system as claimed in any of the preceding claims wherein the slave controller is operable to report the fault condition it has detected to the master controller.

8. A system as claimed in claim 7 wherein the slave controller is operable to report to the master controller in response to an interrogation by the master con-
9. A system as claimed in claim 7 or claim 8 wherein the master controller is operable to initiate a system wide failure condition procedure in response to a fault condition.

10. A system as claimed in claim 9 wherein the system wide failure condition involves switching all the signal units to red or off.

11. A system as claimed in any of claims 8 to 10 wherein the master controller is operable to cause a signal indicative of the failure to be sent to remote central centre.

12. A system as claimed in any of the preceding claims wherein each controller is provided with both master and slave controller capabilities and means for switching between these.

13. A system as claimed in claim 12 wherein the master and/or the slave controllers are implemented via discrete dedicated processors or as discrete software modules operated on a single processor.

14. A system as claimed in claim 13 wherein the master and slave controllers within an individual unit communicate only via an internal communications bus.

15. A system as claimed in any of the preceding claims wherein the or each slave controller comprises a light supervisor for monitoring the status of a signal head of a signal unit and a light controller for controlling of the signal head.

16. A system as claimed in claim 15 wherein the light controller is operable to switch power on and off to individual signal units.

17. A system as claimed in claim 15 or claim 16 wherein the light supervisor functions comprise at least one of: monitoring which light unit(s) is (are) on at a given time; monitoring the light intensity of a given light unit, monitoring the ambient light intensity, and comparing the relative light intensities.

18. A system as claimed in any of the preceding claims wherein the or each slave controller operable to control communications between its associated signal unit and other signal units.

19. A system as claimed in any of the preceding claims wherein the master controller is coupled to one or more other types of signalling unit for communicating with road users.

20. A system as claimed in claim 19 wherein the other type of signalling unit is a display.

21. A system as claimed in any of the preceding claims wherein at least one of the controllers includes a user interface.

22. A system as claimed in claim 21 wherein the user interface is operable to allow at least one of: selecting master control module status (active or inactive); initializing the system at the master controller for registration of all the individual slave control modules of all the signal units, and any other detector and/or signalling units in the control system.

23. A system as claimed in any of the preceding claims wherein the master controller has at least one communication channel for communicating with each of the slave controllers.

24. A system as claimed in any of the preceding claims wherein the required signal state is red or green.

25. A system as claimed in claim 24 wherein the required signal state is amber.

26. A method for controlling a traffic light control system having a plurality of controllers each for controlling a traffic light signal unit, one of the controllers being a master controller and the other or others slave controllers, the method comprising transmitting from the master controller to each slave controller a required signal state for its associated signal unit; and implementing at each slave controller the required signal state, the method being characterised by the slave controller: comparing the actual signal state of its signal unit with its required state as defined by the last required state received from the master controller and activating a failure condition procedure in the event of a conflict between the actual and the required signal states.

27. A slave controller for use in the traffic light control system or method of any of the preceding claims, the slave controller being adapted compare an actual signal state of its associated traffic light signal unit with its required signal state as defined by a master controller and activate a failure condition procedure in the event of a conflict between the actual and the required signal states.

28. A slave controller as claimed in claim 27 that is operable to monitor all signal change system broadcasts to a plurality of slave controllers, maintain a system status record indicating the current signal status of all signal units, compare the signal status of its associated signal unit with the signal status of other signal units, and check for any conflict with the signal status of other signal units.
29. A slave controller as claimed in claim 27 or claim 28 that is reconfigurable as a master controller.
Fig. 2

Fig. 3
Fig. 5