Application Note

Q48 Multi-Point Controller – Radio Communications

Rev 01

Introduction

This document provides guidelines for System Engineers intending to implement applications that integrate The QTech Multi-Point Controller (MPC). It covers operation of the radio system and its behaviour under radio fault conditions. This document should be read in conjunction with the QTech Multi-Point Controller User Guide.

The QTech Multi-Point Controller (MPC) is a centralised controller that communicates with up to eight Digital Wireless Point-to-Point (WP2P) modules via a short-range radio link. It is often referred to as the Q48–MPC because it belongs to QTech's Q48 range of wireless control products. The MPC is denoted as the Master because it polls each of the WP2P (Remotes) periodically in sequential order. Each radio connection from the Master to a Remote is called a Link.

Overview

The MPC's primary function is to read and control the state of digital I/O in the (remotely located) Remotes. Other configurations are possible, such as configuring Remote devices to talk to one another using the MPC to route the messages. Remote I/O can be mapped to digital inputs and outputs on the MPC (or Remotes) using QTech's Configuration editor software QTech – Workbench.

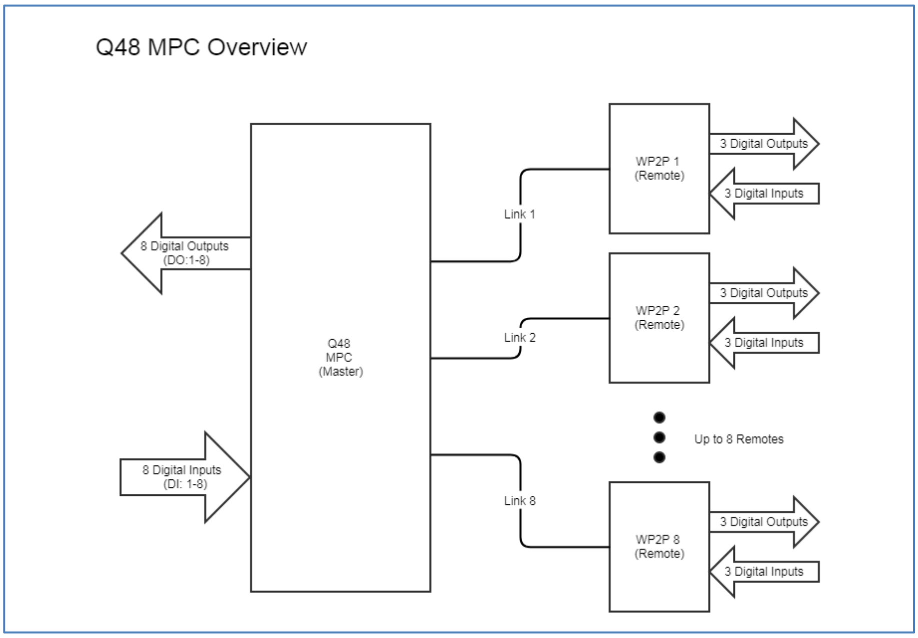

Figure 1. General Overview

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MPC Communication Protocol

The MPC polls each Remote in turn in a round-robin fashion from 1 to R (R being the number of Remotes). The polling period is defined in the MPC configuration. If the period is set to 10 minutes for example, the MPC will poll all remotes and when finished will wait until the 10-minute timer has expired before polling again.

The Protocol uses an ARQ method, whereby the MPC sends a message and if it does not get an acknowledgment it retries sending the message N times (where N is the number of retries) and waits a short period, the Attempt Timeout (A), for a response. If no response is forthcoming the MPC moves on to the next Remote in the cycle but signals an error (called Comms Fail) which is discussed further below.

The communication protocol operates as follows for example:

1. MPC sends a message with the values to set the outputs of Remote1
2. Remote1 responds with the values of its inputs for the MPC, this serves as an acknowledgment that the message from the MPC was received
3. If Remote1 does not respond within the *attempt timeout* time then the MPC resends the message again until the Remote responds or *N retry attempts* have been made, whichever occurs first.
4. Then Remote2 is polled in the same manner and subsequently all the Remotes.
5. Then when the polling period timer expires, the cycle is repeated.

At the end of the polling interval all the inputs and outputs on the MPC are updated. They are not updated immediately after each individual Remote is polled, so if it is critical that the I/O is updated as soon as possible then a shorter polling period must be defined. However, the polling period must be set to longer than the time it takes to poll all Remotes otherwise a new poll will start and the remaining unpolled Remotes will not be polled.

As a rule of the thumb: set the poll period to a number greater than

The number of remotes (R) x number of retry attempts (N) x Attempt Timeout (A)

For example, a unit with 8 Remotes with 3 retries, and an attempt timeout of 500 ms, the polling period must be at least 12000 ms (12s) but in practice a bit more would be added by the System Designer for good measure (say 16s).

In the case of Remotes controlling outputs on other Remotes (via messages to the MPC), it can take up to two poll cycles to complete the update.

Good Practice with Radio Systems Design and Device Layout

The first step in the design is to decide where to locate the Master(s) and Remotes.

❗ When sizing a system, the number of components should be optimised. System designers must determine not only how many Masters and Remotes they need but also the number of Remotes per Master (in a multi-Master system). This can be determined by the amount of I/O required at the Master and Remote ends but this is also limited by the relative proximity or radio range achievable between a Master and each Remote. A rule of thumb is to start by using a map, locate the desired position of the Masters on it and then position each Remote a nominal distance of at most 1 km (line of sight) then proceed with more detailed design once all links have been defined to each Master with link paths minimised. It may help to relocate the Masters to new positions to reduce link distances. Next look at options for radio range extension on difficult links with overly large distances. Distances in excess of 3 km are potentially problematic unless refinements are used.

❗ The System Designer should try to optimise communications in the first instance by:

- Using high grade, 50 ohm impedance matched antennas tuned to the frequencies of interest (915-928 MHz).
- Use as much elevation as practicable when mounting antennas, and use low loss coaxial cabling (for 50 ohm systems).
- Ensure all equipment cases are correctly strapped or wired to earth (remove paint from the case if necessary).
- Use Yagi Antennas with high gain only where the most range is needed.
- Ask QTech if radio repeater options are a viable alternative for the application for increased range.
- Ensure that all cables are suitably tied to avoid fretting and degradation due to wind
- Ensure that trees and foliage in the line of sight are regularly maintained or trimmed.

⚠ For regulatory reasons the Radio Power level for QTech supplied equipment is controlled and set in the factory. It cannot be changed by the Systems Designer or user.

Radio Communications.

Radio communications are never perfect. Radio transmissions are susceptible to a wide range of disturbance which result in errors in the data that is received. In practical terms this results in dropped (rejected or unreceived) messages between the MPC and a Remote. This can be a very temporary issue affecting only one poll cycle. It can also be a problem that degrades over time, appearing to generate communications faults more regularly over many polling cycles. Or it can result in a permanent inability to communicate with a remote. For example:

- The weather can cause an increase in comms faults on a wet and windy or stormy day
- Badly matched antennas can attenuate the signal with only marginal ability to communicate with a Remote sporadically if at all.
- A Remote located too far away or with a hardware fault (including low RF power output) or turned off would likely result in no messages getting through.
- Interference with other transmitters nearby could cause sporadic or bursts of comms faults.
- Tree or foliage growth in the line of sight of MPC and remote could degrade communications over time (experience more communications faults).

❗ Given there is a statistical probability that a communication fault could arise either temporarily or over an extended period, System Designers should design explicitly for the eventuality especially if, for example plant and equipment needs to operate either in a fail-safe manner or should not be turned off due to short temporary communications issues.

Communication Faults

The following Communication Fault definitions are made:

Comms Fail:
If either an MPC or Remote do not receive a response to a message sent by it to its paired device and all retries are exhausted then a Comms Fail fault is asserted in the transmitting device.

If an MPC sends a message to a remote but does not get a response it asserts its Comms Fail Flag and also displays an error code on the display Error led indicating the identity of the Remote that has not responded.

On a Remote, the Link State Led is normally on but will flicker when a message is sent or received by the Remote. It does not indicate a fault condition unless the device is repowered. If the Remote cannot establish communications with the MPC the Link Led will stay off or flash slowly. Link Status is best viewed at the MPC.

A Comms Fail fault can occur on any poll cycle and affect one or more Remotes and can persist or recur under adverse operating conditions or it can be a "one-off" due to a single message being affected.

The fault will remain in place until normal communications are resumed between the MPC and the relevant Remote (or Remotes).

System Designers can use a feature of the MPC to configure an otherwise unused digital output as a Comms Fail output which is asserted (turned ON) whenever a Comms Fail Flag is TRUE (i.e. when there is a comms failure with any Remote) and it is negated (turned OFF) When all Remotes resume normal communications. The facility is configured in Workbench.

Link Fail:
Each radio connection to a Remote is called a link. If communications with a Remote experience a continuous Comms Fail for about 30s this is called a Link Fail Fault. Link Faults are detected in the MPC.

System Fail:
If communications with all remotes are such that they are all in Link Failure this is called a System Fail fault. System Fail faults are detected in the MPC.

Digital Outputs on MPC and Remotes

Both the MPC and WP2P (Remote) have a feature to control the behaviour of their digital outputs in the event of a Comms Fail. They are implemented slightly differently though:

On the WP2P, the device has a physical Switch labelled HOLD:

- When HOLD is switched ON the WP2P will retain the current state of all its digital outputs when in the Comms Fail state.
- When HOLD is switched OFF the WP2P will reset (release) the state of its digital outputs when in the Comms Fail state. This will set all the outputs to their OFF or NEGATED state.

On the MPC, the device is configured in Workbench for each of the 8 digital outputs to enable the HOLD function or the RELEASE function.

- When HOLD is configured as ON (TRUE) for a digital output, the MPC will retain the current state of this digital output when in the Comms Fail state.
- When HOLD is configured OFF (FALSE) the MPC will reset (RELEASE) the state of this digital output when in the Comms Fail state. This will set the output to its OFF or NEGATED state.

System Designers should consider carefully which behaviour is desired. For instance, using the HOLD facility could keep a water pump on and avoid temporary comms faults but other conditions might dictate that it is best to turn it off. On the other hand, if the RELEASE function is used then every time a message is missed (which might be reasonably often on a poor communications link, then the pump will drop out (be turned off), possibly needing manual intervention thereafter.

MPC Behaviour

The MPC cannot be made immune from Comms Fail faults especially sporadic ones. But it does try to minimise the impact.

❗ If a Comms Fail occurs and the HOLD function is configured just for key outputs, others could be released raising a fault condition to be handled by an alarm service, PLC or such like. Alternatively, the MPC could assert its dedicated Comms Fail output (if configured).

❗ Changes of state on the Comms Fail output could be counted or passed to a PLC where decision thresholds (e.g. the number of faults per hour) can be used to take further action.

❗ Changes of state on the Comms Fail output could be measured for duration or used by delay timers and if the comms fail is asserted for longer than a threshold time then further action can be taken.

If a Link Failure occurs the MPC will only RELEASE (reset) those MPC outputs associated with the link in the I/O map and even then, only if those outputs are specifically configured with HOLD disabled (i.e. RELEASE enabled). The MPC will also partially reinitialise its radio module but try to avoid disrupting other links which are otherwise functioning normally.

If a System Failure occurs the MPC will reset itself entirely, it will reset all digital outputs, it will fully reinitialise its radio module and effectively behave as if it has been repowered. If this condition persists it will repeat the process until at least one Remote responds to messages. This can also occur if all Remotes are turned off.

Design Ideas

❗ The following may be of benefit to the System Designer.

QTech recommends that the HOLD function be invoked where possible to avoid the effect of short or bursty communication failures.

In addition, at least one output on the MPC should be dedicated to monitoring Comms Fail faults so that if they persist or of a long duration further action can be taken by a PLC, RTU, alarm messaging service or fail-safe controls.

Remote units that are turned off for any length of time (out of service, say) should be dealt with by modifying the MPC I/O configuration to ignore the remote. Otherwise they will appear to show as Comms Failures.

Alternatively, if there is sufficient I/O available, links can be monitored using a signal or a loopback at the remote or the MPC to check for continuity over the radio link and therefore if continuity is broken then implement alarm or contingency measures. If a loopback signal breaks, for example, local pump control can be instigated to avoid low pressure, or high-pressure faults. Loopbacks are also used to cycle the power on devices as a means of resetting elements of the system.

Symbols that may be used in this document:

Guidance for the System Designer

Warning to the System Designer

Hazard to be fully mitigated in Design

For further assistance, please phone QTech Data Systems Ltd on +64 3 366 3713 or email techsupport@qtech.co.nz.