Pakscan
Cables, Distances, and Communication Speeds

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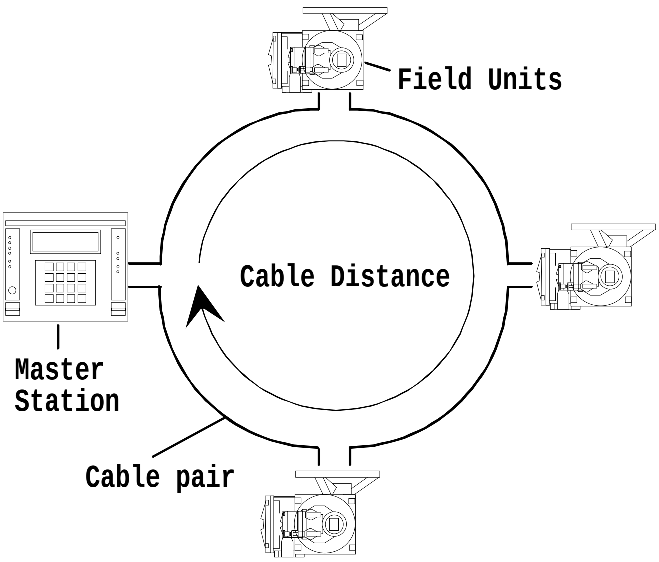
Introduction

Pakscan systems operate over a 2 wire cable that interconnects all the points on the system. The cable must be wired in a ring fashion such that the ring originates at the master station, visits each field unit in turn and eventually returns to the master station. The length of the cable used for the loop will be determined by the site topography and the system performance required. The speed of communicating events will depend on the data baud rate and number of field units. The baud rate is dependant on the number of field units and the cable parameters, its total resistance and capacitance.

Loop Distance

The system uses a 2 wire (1 pair) cable. The length of the *cable* is the circumference of the circle described. This is the total distance covered by the cable around the site.



Notice that the total length of the *conductors* of the cable is 2 times this circumference as it is a cable pair.

Loop Resistance (R)

The total resistance of the loop cable will be the resistance of the 2 conductors added together. Cable suppliers specify the cable resistance in Ohms/km. The figure will be for a single conductor of the stated cross sectional area. The loop resistance is calculated by

Total Conductor Length x Resistance per unit length

The total conductor length is 2 times the cable distance.

Loop Capacitance (C)

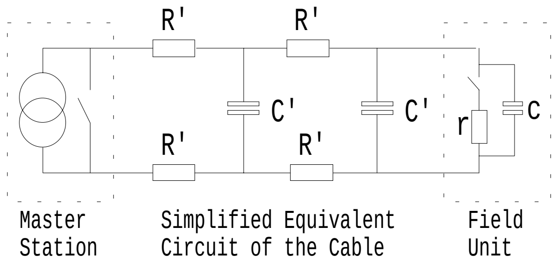
The capacitance of the cable will be the capacitance between the 2 conductors. cable manufacturers specify this figure in nF/m, or pF/m, it will be different for various insulation materials, a particular cable diameter and construction. The total loop capacitance is calculated by

Total Cable length x capacitance per unit length

The total cable length is the cable distance.

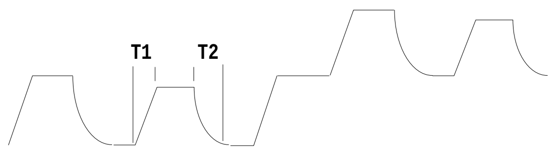
Pakscan Loop Equivalent Circuit

The Pakscan loop distance is limited by the total network capacitance (the capacitance of all the field units plus the capacitance between the conductors) and the total resistance of the two conductors. There are two limiting factors in determining the maximum values for R and C that can be tolerated.



Line Charge Time T1 - the capacitance must be charged to the maximum line voltage by the 20mA current source from the master station.

Line Discharge Time T2 - the capacitance must be discharged to zero by the master station 'switch'.



Line Voltage Waveform

Line charging is virtually independent of line resistance since the master station source is a constant current.

The *line discharge* generates an exponential pulse edge delay.

The master station transmission has to work into the line and field unit total resistance and capacitance whilst the field unit response open circuits the line. The

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value for the line voltage can be adjusted between 9 and 15 volts.

The values tolerated by the system for T1 and T2 are given below:

Baud Rate	$T1_{max} = T2_{max}$ (mSec)
110	2.20 mS
300	0.83 mS
600	0.41 mS
1200	0.21 mS
2400	0.10 mS

Maximum Values for the network R and C

Each field unit contributes to the overall system C and R values. The value of ‘r’ is minimal (less than 1 ohm) and ‘c’ is 2 nF per field unit.

The maximum value of R can be predicted as the current of 20 mA has to be established through the cable and field unit resistance. The absolute maximum value of network resistance that may be tolerated is 750 ohms. The recomended maximum cable resistance is 500 ohms to ensure adequate safey margins.

Maximum Resistance (ohms) of the Cable excluding field units	
Baud	Number of field units
Rate	0 to 240
110 - 2400	500

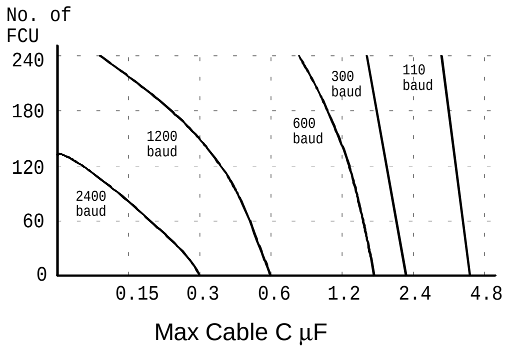
Note: 1 field unit has 1.14 ohms resistance

Predicting the value of C by using a computer modeling programme that simulates the components of the master station, each field unit and the cable the table below may be constructed.

Maximum Capacitance (µF) of the Cable					
Baud	Number of field units				
Rate	0	60	120	180	240
110	4.5	4.36	4.24	4.10	3.97
300	2.1	1.98	1.84	1.70	1.57
600	1.54	1.41	1.27	1.14	1.02
1200	0.6	0.47	0.34	0.20	0.07
2400	0.3	0.17	0.04	N/A	N/A

Note: 1 field unit has 2.2nF capacitance

The maximum values of C for the cable are shown diagrammatically below:



Cables

The recommended cables to use for the loop wiring should be a twisted pair with an overall screen. The construction will usually be copper conductors and pvc insulation. There may be additional outer protection in the form of armour.

This type of cable has a reasonably constant performance characteristic and the following is typical of the cable parameter data found from suppliers such as Beldon and BICC.

Cross Section (mm^2)	Resistance Ω/km	Capacitance pF/m
0.5 solid	36.8 Ω/km	115 pF/m
0.5 flexible	39.7 Ω/km	115 pF/m
1.0 solid	18.4 Ω/km	115 pF/m
1.5 stranded	12.3 Ω/km	115 pF/m

Maximum Loop Distances

From the cable data and the calculations for the maximum permissible resistance and capacitance at each baud rate the maximum cable distances can be derived for each baud rate.

	Loop Distance (km) with $1.5mm^2$ cable		
Baud	Number of FCU		
Rate	60	120	240
110	20.3 km	20.3 km	20.3 km
300	17.1 km	15.9 km	13.7 km
600	12.2 km	11.1 km	8.8 km
1200	4.1 km	2.9 km	0.6 km
2400	1.5 km	0.3 km	N/A

Note that the loop distance is the length of the twisted pair cable including both the cores.

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Communication Speeds

The speed of interest is the time taken by the system to collect data from the field and issue commands to the field. This will dependant on several variables.

Baud Rate - the data transfer bit rate or Baud rate. This is the fundamental speed at which the data bits are transferred along the 2 wire loop.

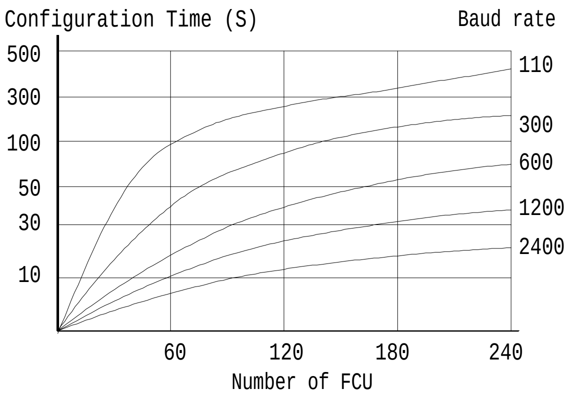
Number of Field Units - the number of field units to be scanned on the 2 wire loop. A small number of field units may be scanned faster for a given baud rate than a large number.

Quantity of Data - the amount of data that is to be transferred from each field unit will affect the time it takes to complete scanning each field unit.

Configuration Time

Configuration is a much more complex process than scanning since the field units have to be identified and their position on the loop recorded. During configuration there are various timeout periods that must elapse.

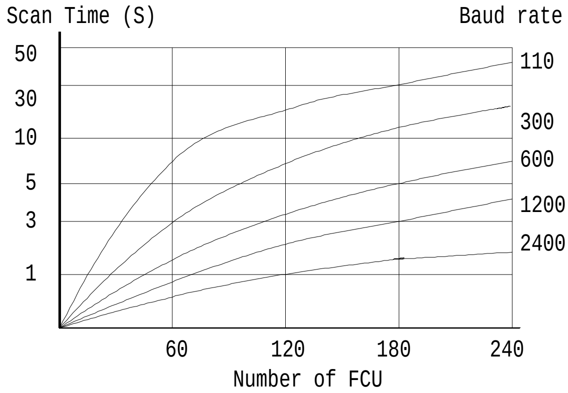
Configuration Times (seconds)					
No. of	Baud rate				
FCU	2400	1200	600	300	110
60	5.4	10.8	21.6	43.2	118.2
120	10.4	20.8	41.6	83.2	227.3
180	15.4	30.8	61.6	123.2	336.4
240	20.4	40.8	81.6	163.2	445.5



Scanning Time

In the tables it is assumed that only one field unit has new data to report. As scans occur all the time the probability is that there is no new data from any unit during a scan as the valves will not have changed position. If all the field units have new data then the scan time approaches half the configuration time.

Scan Time (seconds)					
No. of	Baud Rate				
FCU	2400	1200	600	300	110
60	0.39	0.77	1.54	3.08	8.4
120	0.89	1.77	3.54	7.08	19.3
180	1.39	2.77	5.54	11.08	30.3
240	1.89	3.77	7.54	15.08	41.2



Commands

Commands have priority over status requests. When there is a command to sent to a field unit the status scan is suspended and the command issued. If there are several simultaneous commands to issue these will be interleaved within status requests.

Command Times (milli-sec)

Baud Rate	Time (mSec)
2400	27
1200	54
600	108
300	216
110	432

Command instructions should only be sent when there really is an action required otherwise the scanning time will be increased whilst the commands are processed. If the host DCS or PLC uses Function Code 15 to write multiple commands all the commands will be sent to the field units. The chances are that many will be simply a repeat of an earlier command and if this is the case then there will be no resultant action, the result will be a slowing down of the data collection.

Making the Choice

Determining the decision between loop distance, number of field units and communication speed demands a knowledge of the application of the automation system.

If there is a need to obtain field data quickly then the loop distance will generally have to be kept short. As more field units are added this will have two fold effect, the loop will generally get bigger, so the distance will increase and at the same time there are more connected devices.

In general the longer loops are subject to a limit on the cable resistance whilst the higher speeds are limited by the cable capacitance. The resistance of the cable can be reduced by using conductors with a larger cross sectional area. The capacitance for a pvc cable will generally remain constant.

Special cables are available with reduced capacitance if the application demands. By employing these cables the speed may be increase.

In any decision the resistance of the connections through terminals and junction boxes should not be ignored.

The figures given in these notes have a degree of safety margin. However it is not recommended to design the cable runs without retaining some margin for error.

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