CHAPTER II

ROTECH TOOLING AB
SERIAL COMMUNICATION PROTOCOL EO-1

INSTRUCTION INDEX

COMMUNICATION SPECIFICATIONS

Information is transmitted to the Rotwel over an RS485 communication network. A maximum of 16 (sixteen) weld controls can be networked on one channel(addresses 0-F hex).
Presently, the baud rates available are 9600 and 19.2k. These communication rates are burnt into the EPROM at time of installation. The serial characters are constructed as follows:

1 Start bit
7 Data bits (7 bit ASCII code)
1 Parity bit using even parity
1 Stop bit

MESSAGE FORMAT:
All messages sent to the Rotwel Max-1 must follow a strict format. Which is "[<stx>][a][code]{s}{data}[<ext>][<hpc>][<cr>]". The breakdown follows:

[<stx>]	Required "start of text" character. Hex 02.
[a]	Required Rotwel-Max1 address. Hex 0-F or group address Q-X.
[code]	Required Instruction command.
{s}	Optional schedule or stepper number for some instructions.
{data}	Optional data to be downloaded for some instructions.
[<etx>]	Required "end of text" character. Hex 03.
[<hpc>]	Required "horizontal parity check". Ex-Or of message characters.
[<cr>]	Required "carriage return". Hex 0D.

All message recived from the Rotwel-Max1 will be: "*{info or ack}<etx><hpc><cr>".

RESPONSE WITHOUT DATA:
In case where a response is requested of the Max-1, but not data exists, the Max-1 will respond with an "asterisk", "space"(Char 20H), followed by "ehc", as described elsewhere in this document.

KEY TO CODES USED IN THE EXPLANATIONS

The following codes may be used to indicate elements within a command:

'ack'	ACKnowledge, one character (Hex 02).
'nak'	Not AcKnowledge, one character (Hex 15).
'stx'	Start of transmission (Hex 02).
'ehc'	The group of trailing characters required for transmission, "ETX", "HPC", "CR".
'etx'	End of transmission character (Hex 03).
'hpc'	Horizontal Parity Check, a 7 bit value representing the exclusive OR of all words in a communication, except the "CR".
'cr'	Carriage Return (Hex 0D)
'ENQ' or <05>	The ASCII Enquire character (Hex 05).
'creg'	Current regulation mode.
'vreg'	Voltage regulation mode.

GENERAL NOTES:

1. The command code letters are shown in upper case for example only, the actual communications are "case intensitive".

2. In the following examples, spaces are used to separate groups of characters, although the spaces spaces do not exist in the actual communications.

3. In the following examples, some values are represented by letters, to show what the value pertains to. In the actual message, the numbers for these values would be used, not the characters that represent these values.

4. When a message is not received properly, the WCU will respond with the "NAK" character (15 hexadecimal) followed by the "ehc" codes. With commands that go to multiple WCUs at the same time, the lowest addressed WCU will respond with "NAK".

5. When a message is received properly, and a responsen of information is not required, the response "ACK" followed by "ehc" will be given, to indicate the proper reception of data.

6. An Operation Fault will occur if normal operation of the WCU is disrupted. The bits in the 32 bit fault word have meanings assigned to them as shown in chart #1, "The Operation Fault Word".

7. The WCU will not respond to any communication during welding except the "ENQ" command.

8. The WCU requires several milliseconds following the "U" command for sequence selection to prepare for the next initiation. During this time the following is calculated:
   a) Conversion of stepper and heat values to binary values.
   b) Setting new current and power factor windows.
   c) Calculating heat, slope heat, impulse heat, using stepper boost.

If there is no "U" command, the WCU uses the same conditions as before. This time can be more than 10 millisecs if the "H" command is very long. This time is always less than 100 milliseconds.

9. The WCU has an E Stop input, which must receive 24 VAC at all times. The WCU stops and sets fault bit 27 if the E Stop signal is removed for more than one cycle of time.

ROTWEL MAX-1 INSTRUCTION SET

<05> OR (ENQ) = ENQUIRE FOR BUSY STATUS

PURPOSE; to allow a quick method of determining if any of the WCUs on a communication bus are still busy.

METHOD: The ASCII "ENQ" code, (05 decimal) is sent to the WCUs, without the customary start and end codes, for the sake of speed. All WCUs that are busy will answer back at the same time.

SYNTAX: "enq" or ASCII "05"

RESPONSE OF WCUs:

1) A "break" of 2-3 characters in length.

The response is sent on the next available cycle of the line frequency, or no later than 17 milliseconds. No response is received from a WCU that is not busy. This departs from the usual response of "ack" for this condition, but the command is optimized for speed. If more than one WCU answers, there will be a data collision, which is unimportant to the process, but may require special considerations in the receiving device.

H = HEAT SEQUENCE DOWNLOAD

PURPOSE:
1. To load a selected sequence (weld schedule) (out of 16 total) into a selected WCU. Maximum length of the sequence = 128 bytes. The WCU can hold 16 sequences, numbered 0-F hex, each 128 bytes long.

METHOD:
1. The command containes the sequence information and values. The sequence can be constructed of the following subcommands, most can be used any amount of time in any order. An example of a complete sequence to the WCU follows the individual explanations. The WCU address, and schedule selected, are built into the instruction.
"Creg" and "Vreg" refer to the mode that the WCU is set-up in, "current regulation" or "Voltage regulation". See the "ZOM" instruction.

INDEX OF SEQUENCE SUBCOMMANDS:

H = HEAT	Creg mode: "H scc cc" (current/cycles): Vreg mode: "H rms cc" (% volts/cycles)
I = INCREMENT STEPPER*	"I t" (stepper #)
K = KILL TIME (wait)	"K cc" (cycles)
L = VOLTAGE SLOPE	"L rms rms cc" (start/end/cycles)
M = IMPULSE HEAT	Creg mode: "M scc hh cc xx" (curr/cycles/cool/times) Vreg mode: "M rms hh cc xx" (%volts/cycles/cool/times)
N = NEW CURRENT WINDOW	Creg: "N scc scc" (% curr low/high) Vreg: "N per per" (% voltage low/high)
O = OPEN LOOP VOLT IMPULSE	"O rms hh cc xx (%volts/cycles/cool/times)
P = POWER FACTOR LIMIT SETUP*	"P lo hi" (pf % low/% high)
R = RATIO OF TRANSFORMER*	"R rrr" (ratio) (Ratio has no meaning in Vreg mode)
S = SLOPE HEAT	Creg mode: "S scc scc cc" (start/end/cycles) Vreg mode: "S rms rms cc"(%volts instead)
T = TIP SENSING INITIATION*	"T1" or "T0" (on-off)
V = VOLTAGE WAIT, TIMED	"V vvv cc" (min volts/cycles)
W = REWELD ON LOW CURRENT*	"W1" or "W0" (on-off)

*THESE SUBCOMMANDS (I,P,R,T & W) CAN BE USED ONLY ONCE PER SEQUENCE.

The maximum length of a communication packet to the WCUs is limited to 128 characters. Therefor the maximum length of a sequence is limited to 128 - 7 or 121 characters (7 equals the "saIIs...ehc" characters needed to "package" the data to the WCU).

NOTE: THIS COMMAND CAN BE DIRECTED TO ALL WCUS BY USING THE ALL CALL ADDRESSES Q THROUGH X.

H = HEAT

This generates weld power in secondary amps, or % heat, for a number of cycles, 00 through 99. Note that this command will generate a "fault" upon initiation if the heat or cycles are greater than the limits loaded into the WCU with the "O" (Operating Parameters) command.

SYNTAX: Creg mode: "H acc cc"
Vreg mode: "H rms cc"

"scc" = secondary amps: (00000-99900/100).
"rms" = % heat: (000% to 100%).
"cc" = number of cycles: (00-99).

I= INCREMENT STEPPER
Causes the selected stepper "t" (0-F) to be incremented and also control the boost of the heats. Note all current windows will be adjusted by the boost value to "track the stepper" selected by this instruction.

SYNTAX: "It"

"t" = stepper number 0-F hex.

THE INCREMENT STEPPER INSTRUTION WILL NOT INCREMENT THE STEPPER COUNT IF ANY OF THE FOLLOWING OCCUR;

A) Weld sequence aborts by any fault.
B) Emergency stop occurs.

K= KILL TIME (Wait)
Causes the control to simply wait and do nothing for a number of cycles, 00-99. Used for steps such as squeeze, hold, cool, and off.

SYNTAX: "K cc"
"cc" = number of cycles 00-99

L = VOLTAGE SLOPE
Provides the user a way to slope in voltage mode when the default mode is set for current. This allows the switching from voltage mode to current mode during the welding sequence.

SYNTAX: "L rms rms cc"
"rms" =starting voltage heat level (000-100%)
"rms" = ending voltage heat level (000-100%)
"cc" = slope time in cycles (00-99)

Heat Sequence Download Continued

M = IMPULSE HEAT
Where a weld pulse is repeated to give 01 through 99 total pulses, with cool cycles of 00 through 99 between them. Note that using "00" or "01" for the no. of impulses will result in a single impulse only. Note that if the current values exceed the limits set in the Operating parameters, it will cause a fault.

SYNTAX: Creg mode: "M scc hh cc xx"
Vreg mode: "M rms hh cc xx"

"scc" = secondary current amps (00000-99900/100)
"rms" = heat in Vreg mode 000% to 100%
"hh" = the number of weld cycles 00-99
"cc" = the number of cool cycles between pulses 00-99
"xx" = is the number of impulses 01-99

N = NEW CURRENT WINDOW SETUP
This sets lower and upper limits of secondary current at the point in the sequence that the WCU encounters this instruction. The first set of values are the lower limit, the second set are the high limit. Using this instruction many times allows the monitoring of different values for different areas of a complex heat command.

The limits are calculated at the time of initiation. The boost of the stepper, and the lowest and highest currents in the entire sequence (depending on the placement of the "N" command.) are figured into the calculation, so that "Stepper Tracking" is performed. Note that in the current mode, true stepper tracking is performed, because, unlike the voltage mode, the WCU knows what the expected current should be, and does not have to "follow" the resultant current as a conventional control must. In the voltage mode, this window refers to voltage out of the WCU, so still performs "Stepper Tracking", but on voltage values, not current values.

Note that there are low and high primary current settings also, see "Operating Parameter Download" instruction ("O"). The values calculated during sequencing are "mean" values, based on all the cycles of heat in a particular subcommand.

SYNTAX: Creg mode: "N scc scc"
Vreg mode: "N rms rms"

first "scc" = low secondary current window 000%-100%
second "scc" = high secondary current window 100%-200%
first "rms" = % deviation allowed for low heat 000%-100%
second "rms" = % deviation allowed for hi heat 100%-200%

O = OPEN LOOP VOLT IMPULSE
Allows an impulse weld to bypass the initial soft start 3 cycles of the firing sequence. Used when it is required to make a high quality weld in a short period of time (such as 3-4 cycles).

Heat Sequence Download Continued

SYNTAX: "O rms hh cc xx"

"rms" = weld heat in voltage (000-100)
"hh" = weld time in cycles (00-99)
"cc" = cool cycles between pulses (00-99)
"xx" = number of pulses (01-99)

P = POWER FACTOR LIMIT SETUP
Sets lower and upper power factor limits at the point in the sequence that the WCU encounters this instruction. The first set of values are the lower limit, the second set are the high limit.

SYNTAX: "P lo hi"

"lo" = low limit (00-99)
"hi" = high limit (00-99)

R = TRANSFORMER RATIO SETTINGS
For specifying the turns ratio of the transformer used in this sequence. If this Ratio Setting command does not exist within the sequence, then the ratio setting defaults to the setup in the Operating Parameters (see "O" command). The value can be adjusted slightly to allow precise calibration of the currents.

SYNTAX: "R rrrr"

"rrrr" = primary turns divided by secondary turns (000.1-199.0)

S = SLOPE HEAT
Where the heat starts at one current, then over a number of cycles, changes to the end heat. Note that exceeding the values in the operating parameters causes a fault.

SYNTAX: Creg mode: "S scc scc cc"
Vreg mode: "S rms rms cc"

first "scc" = starting heat (00000-99900/100)
second "scc" = ending heat (00000-99900/100)
first "rms" = % starting heat (000-100)
second "rms" = % ending heat (000-100)
"cc" = number of cycles (00-99)

T = TIP SENSING INITIATION
Which enables or disables this feature for the sequence that this subcommand exists in. Note that it does not matter where in the sequence this subcommand is, it always acts as if it is the first subcommand. For clarity, it should be the first step.

Heat Sequence Download Continued

This causes the control to fire the Thyristor at a low phase angle, looking for a sudden increase in current, as will occur when the tips touch the part. At that time, the WCU will continue with the rest of the sequence. NOTE, the "ZCN" command must be set to allow a low current of "000", otherwise an "Undercurrent Fault" will occur before the tips come together. There is a timeout of 5 seconds on this feature.

SYNTAX: "T1" to enable, "T0" or not present to disable

V = VOLTAGE WAIT, TIMED

For causing the WCU to wait until a certain minimum voltage is available on the welding bus before it proceeds to the next instruction. This command "times out" in a certain number of cycles, and the WCU then proceeds to the next instruction in the heat sequence.

SYNTAX: "V vvv cc"

"vvv" = minimum voltage the WCU must wait for.
"cc" = maximum number of cycles WCU will wait for the minimum volts.

W = WELD AGAIN ON LOW CURRENT

Causes the WCU to "reweld" if any current was below the limit set by the current window. The sequence gets repeated, once only. If on the second try there is still a low current, the fault bit will be set. If the second weld was successful, there will be no indication that this situation has occurred. This is used after all the heat instructions, near or at the end of the sequence.

SYNTAX: "W1" to enable, "W0" or not present to disable.

EXAMPLE OF A COMPLETE SEQUENCE DOWNLOAD

SYNTAX (of a complete instruction):

"3H1T1I7K17S06315012H16522"

Which represents the following steps for WCU #3 sequence #1;
KILL 17 CYCLES (squeeze).
TIP SENSING INITIATION ENABLED.
INCREMENT STEPPER #7, USE IT FOR BOOST OF HEATS AND CURRENT WINDOWS.
SLOPE HEAT FROM 6300 AMPS TO 15000 AMPS, IN 12 CYCLES.
HEAT AT 16500 AMPS FOR 22 CYCLES.

RESPONSE OF WCU: Either "ack" for an acceptable sequense, or "nak" for a communication error.

I = INITIATE WCU

PURPOSE: To start the WCU so that it will perform the steps in a selected sequence. Note that the sequence must reside in the WCU's memory before it can use it. The command can contain the sequence number desired or if the seq number is not included, it will use the same as the last time it was initiated. Note, read the information under "U" command.

METHOD 1, initiation of individual WCU:

SYNTAX: "a I" or,
"a I s"
"a" = address of WCU to initiate
"s" = sequence number desired

RESPONSE OF WCU: "ack", or if the WCU detects a checksum error, it will respond with "nak".

METHOD 2, initiation of all WCUs in a group:

SYNTAX: "g I" or,
"g I s"
"g" = the ASCII character that represents the group of WCUs (Q-X)
"s" = sequence number desired

RESPONSE OF WCUs: The lowest addressed WCU will respond "ack", or if the WCU detects a checksum error, it will respond with "nak".

M = MEMORY CLEAR

PURPOSE: To clear schedule and/or stepper information in a selected WCU.

METHOD: The command holds;
(1) The address of the WCU
(2) The bits in two sixteen bit words set to indicate which sequences and which steppers to clear. Note that the "RC" (Request Catalog) command can be used to find out which sequences and steppers are programmed.

SYNTAX: "a M yyyy zzzz"
"a" = address of WCU
"yyyy" is four characters 0000-FFFF to represent the sixteen bit word for selecting the sixteen sequences.
"zzzz" is for selecting the sixteen steppers.

RESPONSE OF WCU: "ack", or if the WCU detects a checksum error, it will respond with "nak".
NOTE: This command can be directed to a group of WCU's by using a group address in place of the WCU address.
NOTE: See command "RC" for an example of the hexidecimal representation of a 16 bit word.

O = OPERATING PARAMETER DOWNLOAD

PURPOSE: To setup all the operating parameters in the WCU. These values are to be used, unless overridden by a subcommand in the sequence initiated. Example of this is the "R" command overrides #5 below.

METHOD: The command starts with the address of the WCU, then includes all the setup values in the following order;

1. LOW PRIMARY CURRENT LIMIT	4 digits ("pcur") 0000-9999
2. HIGH PRIMARY CURRENT LIMIT	4 digits ("pcur") 0000-9999
3. PRIMARY BUS VOLTAGE	3 digits ("vvv") 000-999
4. MAXIMUM HEAT CYCLE LIMIT,*	2 digits ("cc") 00-99
5. TURNS RATIO SETTING	4 digits ("rrrr") 0001-1990
6. MAXIMUM SECONDARY CURRENT (/100)	3 digits ("scc") 000-999

* Max Cycles refers to the max cycles allowable for each of the subcommands of the "H" command that does welding, such as "H", "M", and "S".

SYNTAX: "a O pcur pcur vvv cc rrrr scc"

"a" = address of WCU
"pcur" = primary current value (0000-9999)
"vvv" = line voltage value (120-575)
"cc" = number of cycles (00-99)
"rrrr" = turns ratio of transformer (000.0-999.9)
"scc" = secondary current value (00000-99900/100)

RESPONSE OF WCU: "ack", or if the WCU detects a checksum error, it will respond with "nak".
NOTE: This command can be directed to a group of WCU's by using a group address in place of the WCU address.

P = PRE-SET STEPPER COUNT

PURPOSE: To change the present weld count within a stepper.

SYNTAX: "a P n cten"

"a" = the WCU address (0-F hex)
"n" = the stepper number (0-F hex)
"cten" = the new count (/10) for that stepper, 4 digits to represent counts of 00000-99990

RESPONSE OF WCUs: Either "ack" for an acceptable sequence, or if the WCU detects a checksum error, it will respond with "nak".

NOTE: This command can be directed to a group of WCU's by using a group address in place of the WCU address.

Q = QUERY WCU

PURPOSE: To idintify which WCUs are no longer busy sequencing, and if there were any operation faults encountered. If the weld control is still busy, there will be no response.

METHOD 1: Individual interrogation:
This instruction is sent to a single WCU, and contains the appropriate address.

SYNTAX: "a Q"

"a" = address of WCU

RESPONSE OF WCU: "n". The "n" is used to signify the fault status, and could can be any number 0 through 9 to show:

0 = No faults
1 = Current Problem (fault bits 0,1,14,16,17or 26)
2 = Communication Error (fault bit 2)
3 = SCR Problem (fault bits 3,5 or 6)
4 = End of Stepper Detection (fault bit 7)
5 = Touchdown time out (fault bit 9)
6 = Power Factor out of limits (fault bit 13)
7 = Power Problem (fault bits 10 or 24)
8 = Data Weld-1 Setup Problem (fault bits 8, 11, 12, 15, 18-23 or 25)
9 = Emergency Stop Detected (fault bit 27)

If the WCU detects a checksum error, it will respond with "nak ehc".

METHOD 2: Interrogation of all WCUs at once:
This instruction is sent to all the WCUs, and if not busy, they respond in the order of their address with their fault status, as above.

SYNTAX: "g Q"

"g" = group address of WCU's

RESPONSE OF WCUs: "n" "n" "n"...
If the lowest addressed WCU detects a checksum error, it will respond with "nak". Note that "n" indicates fault status, as in the chart above.

TIMING: The entire communication takes 89 milliseconds at 9600 baud. Any WCU that doesn't respond in 2 milliseconds, will be skipped, which will shorten the communication time in some cases.

RC = REQUEST CATALOG

PURPOSE: To find out which schedules and steppers are programmed and to get the amount of memory left in the WCU.

SYNTAX: "a RC"
"a" = address of WCU

RESPONSE OF WCU: "xxxx yyyy zzzz"

"xxxx" = hexidecimal representation of a 16 bit word representing the weld schedules 0 thru F
1 = programmed, 0 = clear.

e.g: Schedule numbers	FEDC	BA98	7654	3210
Programmed	0101	0010	1101	0011
Hex representation	5	2	D	3

Therefore: "xxxx" above = "52D3" So schedules E, C, 9, 7, 6, 4, 1 and 0 are presently programmed.

"yyyy" = hexidecimal representation of a 16 bit word representing the steppers 0 thru F.
1 = programmed, 0 = clear.
See "xxxx" above.

"zzzz" = Memory available 0000-9999 bytes.

If the WCU detects a communication error, it will respond "nak".

RH = REQUEST HEAT SEQUENCE INFO.

PURPOSE: To obtain the entire contents of one of the heat sequences programmed into the WCU.

SYNTAX: "a RH s"
"a" = Address of WCU desired 0 thru F
"s" = Sequence number desired 0 thru F

RESPONSE OF WCUs: The entire sequence will be sent back out of the WCU e.g. "13N080120P7882H11523", which means;

"I" = Use stepper number "3" for boost, and increment it.
"N" = New current window of 80% to 120%.
"P" = Power factor window of 78 to 82.
"H" = Heat at 11500 amps for 23 cycles.

See "H" (Heat download command) for a complete list of the subcommands.

If the WCU detects a communication error, it will respond "nak".

RL = REQUEST LAST WELD DATA

PURPOSE: To obtain information about the last weld performed by the WCU.

SYNTAX: "a RL"

"a" = address of the WCU 0 thru F.

RESPONSE OF WCU: "vvv pcur scc pf cten cten t"
(or "nak" if comm error) where:

"s" = sequence number last welded. (0-F)
"vvv" = lowest line volts of last weld, 000-999.
"pcur" = highest primary current of last weld 0000-9999.
"scc" = highest secondary current (/100) of last weld.
"pf" = average power factor of last weld, 00-99.
"cten" = stepper count (/10) of last stepper used.
*"t" = stepper last used, 0-9, A-F.

* If there was no stepper used or the stepper was turned off, there will be a space in this location.

RO = REQUEST OPERATING PARAMETERS

PURPOSE: To recover the operating parameters information, originally loaded into a WCU with the "O" command.

SYNTAX: "a RO"

"a" = address of the WCU

RESPONSE OF WCU: The entire operating parameters are is sent back out of the WCU:
"pcur pcur vvv cc rrrr scc" (or "nak" if error)

This includes all the setup values in the following order;

1. LOW PRIMARY CURRENT LIMIT	4 digits ("pcur") 0000-9999
2. HIGH PRIMARY CURRENT LIMIT	4 digits ("pcur") 0000-9999
3. PRIMARY BUS VOLTAGE	3 digits ("vvv") 000-999
4. MAXIMUM HEAT CYCLE LIMIT	2 digits ("cc") 00-99
5. TURNS RATIO SETTING	4 digits ("rrrr") 000.1-199.9
6. MAXIMUM SECONDARY CURRENT (/100)	3 digits ("scc") 000-999

RP = REQUEST PRESENCE OF WCU

PURPOSE: To idintify the WCUs that are active on the communication line.

METHOD: This instruction is sent out to all (or one) WCUs, and they respond, in order of their assigned address. In each WCU, the address is multiplied by the response length plus any required guard space, and this is used as a delay in responding. Each WCU responds with its own address, 0 through F. As with the "Q" command, the WCUs may answer back faster if they detect missing responses "in between".

SYNTAX: "a RP"
"a" = the address of the WCU

RESPONSE OF WCUs: "n""n""n"...(or "nak" if comm error)
"n" = the address of the responding WCU.

NOTE: This command can be directed to a group of WCU's by using a group address in place of the WCU address.

RT = REQUEST STEPPER INFORMATION

PURPOSE: To recover the stepper setup information in a WCU, for a certain stepper number.

SYNTAX: "a RT s"
"a" = the WCU number 0 thru F.
"s" = the stepper number 0 thru F.

RESPONSE OF WCU: The entire stepper setup is sent out the WCU, with following information;
"cten" = ongoing stepper count (/10) 00000-99990.

Then, the following data is sent from the WCU; repeated for each programmed step is;
"cten bbb" = count (/10) and boost (secondary amps /100) of each step, repeated until all steps are reported.
NOTE, when in Vreg mode "bbb" is a boost value of 000% to 100%.

CREG MODE:
Example, for a stepper that has 6 steps programmed:
"0254 0100 020 0200 035 0300 046 0400 056 0500 065 0800 070 ehc"
which means;
Total accumulated stepper count at this time = 2540 welds
Step 1 boosts 2000 amps between count 0 and count 1000
Step 2 boosts 1500 more amps between counts 1001-2000
Step 3 boosts 1100 more amps between counts 2001-3000
Step 4 boosts 1000 more amps between counts 3001-4000
Step 5 boosts 900 more amps between counts 4001-5000
Step 6 boosts 500 more amps between counts 5001-8000

VREG MODE:
Example, for a stepper that has 6 steps programmed:
"0254 0100 020 0200 035 0300 046 0400 056 0500 065 0800 070 ehc"

Total accumulated stepper count at this time = 2540 welds
Step 1 boosts 20% between count 0 and count 1000
Step 2 boosts 15% more between counts 1001-2000
Step 3 boosts 11% more between counts 2001-3000
Step 4 boosts 10% more between counts 3001-4000
Step 5 boosts 9% more between counts 4001-5000
Step 6 boosts 5% more between counts 5001-8000

If a communication error exists, the response will be "nak".

RU = REQUEST DIAGNOSTIC UN - MASK

PURPOSE: to interrogate the 32 bit fault "un-mask word" in a WCU, to determine how it is setup.

SYNTAX: "a RU"

"a" = address of WCU

RESPONSE OF WCU: "xxxx yyyy", (or "nak") with the bits indicating the un-mask setup.

Where:
"xxxx" is the hexidecimal representation of the high 16 bits, 31-16.
"yyyy" is the hexidecimal representation of the low 16 bits, 15-0.

SEE CHART #1, OPERATION FAULT WORD, for further information on the indication of the bits in the fault word. Also, see command "RC" for an example of the hex representation of 16 bit word.

S = SET FAULT UN - MASK / RESET FAULTS

PURPOSE:
1. To set-up which of the thirty-two diagnostic routines will be performed.
2. To reset the fault indications.

METHOD 1:
A 32-bit word is sent out to an addressed WCU, with the bits set to "1" for the desired diagnostics. Note that if the bit is set to "0", the detection still occurs, but the shutdown (where applicable) and announcement with the "Q" command does not occur. Note that some faults may not reset if the condition still exists at the time of reset, such as "OVERTEMP" or "EMERGENCY STOP".

The faults are cumulative, that is if they are not cleared before a new fault occurs, the new fault is added to the bits in the fault word.

SYNTAX: "a S xxxx yyyy"
"a" = address of WCU
" xxxx" = high 16 bits of the unmask word, bits 31-16.
"yyyy" = low bits, bits 15-0.

RESPONSE OF WCU: "ack", or if the WCU detects a checksum error, it will respond with "nak".

METHOD 2: To reset fault conditions but not change the fault un-mask word, send down just the "S" with the appropriate address.

SYNTAX: "a S"
"a" = address of WCU

RESPONSE OF WCU: "ack", or if the WCU detects a checksum error, it will respond with "nak".

SEE CHART #1, OPERATION FAULT WORD, for explanations of the fault conditions.

NOTE: This command can be directed to a group of WCU's by using a group address in place of the WCU address.

T = STEPPER DOWNLOAD

PURPOSE; to setup a stepper in a WCU. The WCU can hold 128 bytes for each of 16 steppers. This allows for 17 "steps", maximum, although most stepper sequences can be described in 4 or 5 steps. The incrementation of current occurs every second weld, and the max stepper count is 99,990.

SYNTAX: "a T s cten bbb.....cten bbb".
"a" = address of WCU
"s" = stepper # (0 thru F)
"cten bbb" = count (/10) and boost (secondary amps /100) of each step, repeated until all steps are described.

The maximum number of steps = 17, there is no minimum number, although it is customary to use only 4 or 5.

NOTE: in the Vreg mode "bbb" represents a % boost figure 000-100%.

RESPONSE OF WCUs: Either "ack" for an acceptable sequence, or "nak".

NOTE: This command can be directed to a group of WCU's by using a group address in place of the WCU address.

STEPPER ON/OFF

Turning the stepper on and off is performed by the using of T command as in downloading a stepper. To turn the stepper on or off, send the following:

aTs0 To turn a stepper off, or
aTs1 To turn a stepper on.

where: "a" is the WCU address, and
"s" is the desired stepper number (0-F).

The process for retrieving the on/off status for the steppers is less straight forward than most of the Rotwel-Max1 protocol. You must use the READ MEMORY (ZR) function to look directly at the RAM locations for this information.

The status for all 16 steppers is held in RAM locations 8004 and 8005, the most significant byte (steppers 8-F) are held in higher address (8005).

To retrieve this information, send the following command to the desired WCU:

aZR800402
where: "a" is the address of the WCU.

This will retrievev memory starting at location 8004 for 2 bytes. The response will be:

***8004: wz yz**
where:
8004 is the WCU echoing back the starting address of memory read,
"w" is a hex digit (0-F) containing four binary bits representing stp´s 7-4,
"x" is a hex digit (0-F) containing four binary bits representing stp´s 3-0,
"y" is a hex digit (0-F) containg four binary bits representing stp´s F-C, and
"z" is a hex digit (0-F) containg four binary bits representing stp´s B-8.

If the binary bit representing one of the steppers is set (equals a 1), the stepper status is **OFF**.
If the representing bit is reset (equals a 0), the corresponding stepper status is **ON**.

EXAMPLE:
send: 0ZR800402
receive: *8004:13 0B

where: w = 1h
x = 3h
y = 0h, and
z = Bh

w breaks down to 0001, therefore stepper #4 is OFF.
x breaks down to 0011, therefore stepper #´s 1 and 0 are OFF.
y breaks down to 0000, therefore steppers F,E,D and C are all ON.
z breaks down to 1011, therefore steppers #´s B,9 and 8 is OFF.

U = USE SEQUENCE NUMBER

PURPOSE: To setup sequence selection, before initiation of the WCU. This command causes the WCU to calculate boost values and perform complete error checks on the contents and validity of the sequence being selected.

This command can be eliminated by incorporating it into the "I" command. See "I" command for more details.

Note that this instruction will require 10 milliseconds or more for processing. The maximum amount of time required depends on the length of the sequence programmed, but is never more than 100 millisecs.

The formula for calculating process time is as follows;
TIME = 3.2+(0.5*K)+(0.7*V)+(2.0*M)+(3.0*S)+(2.0*H)+1..5*N) MILLISEC
Where;

K = Number of "V" subcommands
M = Number of "M" subcommands
S = Number of "S" subcommands
H = Number of "H" subcommands
N = Number of "N" subcommands

"T" and "W" subcommands require an insignificant amount of time.

Since this is when errors in the sequence are discovered, it is recommended to issue a "W" command after this command, to see if there are errors, before the "I" command is given for initiation.

If the "U" command is not given before an "Initiate" command, the WCU will initiate on the sequence that was setup by the last "U" command, and no new values for stepper boost will be calculated. Note that the effect of the last "U" command is cleared upon power up.

SYNTAX: "a U s"
"a" = address of WCU
"s" = sequence number.

RESPONSE OF WCU: "ack", or if the WCU detects a checksum error, it will respond with "nak".

NOTE: This command can be directed to a group of WCU's by using a group address in place of the WCU address.

W = WHAT FAULTED

PURPOSE: To identify the faults that have occured on a particular WCU since the last reset. Note, this command does not reset the faults.

METHOD 1: Interrogation of one WCU to retrieve the fault word.

SYNTAX: "a W"
"a" = address of WCU

RESPONSE OF WCU: "xxxx yyyy"
If the WCU detects a checksum error, it will respond with "nak ehc".
"xxxx" = hexidecimal representation of high 16 bits (31-16) of the fault word.
1=fault, 0=clear.
"yyyy" = hexidecimal representation of the low 16 (15-0) bits of the fault word.
1=fault, 0=clear.

Please see command "RC" for an example of hex represented 16 bit words.

METHOD 2: Overall interrogation of all WCUs:
This instruction causes the WCUs that have faults to answer back with their address. Those that do not have faults will not respond. The WCUs answer back in the order of their address. Because the address of the WCU is used for timing, to avoid data collision, there may be blank spots in the total reply.

SYNTAX: "g W"
"g" = the group address of WCU's

RESPONSE OF WCUs: "n"n"...
"n" = address of a WCU with a fault.

SEE CHART #1, OPERATION FAULT WORD, for further information.

ZCA = VIEW AND/OR CHANGE THE GROUP ADDRESSING.

PURPOSE: To view and/or change the group addressing of a particular WCU. The group addressing is used by those commands which have the ability to address a group of weld controls at the same time. Valid groups are: Q, R, S, T, U, V, W and X. A Rotwel-Max1 welding control can have any combination of group labels.

METHOD 1: To view the group address settings in a WCU.

SYNTAX: "a ZCA"
"a" = address of the WCU

RESPONSE: "GROUP ADDRESS = n"
"n" = any combination of letters from Q thru X to indicate present address settings.

METHOD 2: To change the group address in a WCU.

SYNTAX: "a ZCA n"
"a" = address of the WCU
"n" = any combination of letters from Q thru X to indicate target address settings.

RESPONSE: "ack" or "nak".

ZCC = VIEW AND/OR CHANGE CURRENT CALIBRATION

PURPOSE: To enter values into EEprom and RAM for linear calibration of current readings.

METHOD 1: To recover the values presently in RAM;

SYNTAX: "a ZCC"
"a" = address of the WCU

RESPONSE: "s(0 = ON: 1 = OFF), wrat, scl, sch, mcl, mch(x100A) =
0,0620, 100, 200, 106, 203"
(Note, the values shown in this example are the "factory values" that exist after issuing a "ZT" command.)
s = Switch from compensate (normal) mode, (0): to calibrate mode (1).
wrat = Winding RATio of the transformer.
scl = Set Current Low, the low value used for calibrating.
sch = Set Current High, the high value used for calibrating.
mcl = Measured Current Low, the value read on a current meter.
mch = Measured Current High, the second measured value.

The current values are "Amps X 100".
The data that follows shows the actual values of these parameters.

METHOD 2: To enter new values into RAM and EEprom.

SYNTAX: "a ZCC s wrat scl sch mcl mch"
"a" = address of the WCU
"s" = Switch from compensate (normal) mode, (0) to calibrate mode (1).
"wrat" = Turns ratio of the transformer.
"scl" = Set Current Low, the low value used for calibrating.
"sch" = Set Current High, the high value used for calibrating.
"mcl" = Measured Current Low, the value read on a current meter.
"mch" = Measured Current High, the second measured value.

RESPONSE: "ack" or "nak"

ZCD = CHANGE DISPLAYED VALUES

PURPOSE: To enter values into EEprom and RAM for the desired values to use in the response to the weld trace command (ZRW)

METHOD 1: To recover the values presently in RAM.

SYNTAX: "a ZCD"
"a" = address of the WCU

RESPONSE: "a(0 = 1.052: 1 = 1.0deg), p(0 = 1.052: 1 = 1.0deg: 2 = 100*COS), v(0 = A/D: 1 = V: 2 = %), h(0 = A/D: 1 = PRIM: 2 = SEC) = 1,1,1,2 ehc.

"a" = Angle units, every 1.052 degrees, or every degree.
"p" = Power factor units, 1.052 deg, 1.0 deg, or cosine value (x100).
"v" = Voltage value, A/D convertor output, actual volts, or % of nominal volts.
"h" = Heat units, A/D converter output, primary current in amps, or secondary current in amps x 100.

The data that follows shows the settings of these parameters.

METHOD 2: To enter new values in RAM and EEprom.

SYNTAX: "a ZCD a p v h"
"a" = address of WCU
"a" = (second one) Angle units, every 1.052 degrees, or every degree.
"p" = Power factor units, 1.052 deg, 1.0 deg, or cosine value (x100).
"v" = Voltage value, A/D convertor output, actual volts, or % of nominal volts.
"h" = Heat units, A/D converter output, primary current in amps, or secondary current in amps x 100.

RESPONSE: "ack" or "nak"

ZCF = CHANGE FIRING ANGLE COMPENSATION

PURPOSE: To enter values into EEprom and RAM for compensation of any offset firing that results from firing a nonlinear load, such as a half wave DC machine.

**********IMPORTANT**********

NOT TO BE USED WITHOUT FIRST CONSULTING ROTECH TOOLING.
FIRING ANGLE COMPENSATION THAT IS NOT NEEDED CAN CAUSE TRANSFORMER SATURATION. IT IS ADVISED TO KEEP THIS AT "ZERO-ZERO".

****

METHOD 1: To recover the values presently in RAM;

SYNTAX: "a ZCF"

RESPONSE: "f, r (FIRING ANGLE COMPENSATION 0-7) = 0,0"
"f" = Front Thyristor or the "lead" Thyristor.
"r" = Rear or "trail" Thyristor.

The values are in degrees.
The data that follows shows the actual values of these parameters.

METHOD 2: To enter new values in RAM and EEprom.

SYNTAX: "a ZCF f r"
"a" = address of WCU
"f" = Front Thyristor or the "lead" Thyristor.
"r" = Rear or "trail" Thyristor.

The values are in degrees.

RESPONSE: "ack" or "nak"

ZCG = CHANGE GAIN OF CURRENT FEEDBACK

PURPOSE: To enter values into EEprom and RAM for setting up the current feedback gain factor. Setting this value lower reduces "hunting" or an uneven current cycle-to-cycle. Increasing this value causes the correction to occur faster.

**********IMPORTANT**********

ROTECH ADVISES THAT YOU CONTACT THEM FOR ASSISTANCE BEFORE ADJUSTING THESE VALUES.

****

METHOD 1: To recover the values presently in RAM;

SYNTAX: "a ZCG"
"a" = address of WCU

RESPONSE: "cpg, cig, vpg, vig (GAIN 000-255) = 128, 128, 128, 128"
(Note, this example shows the "factory values" for gain, as entered with the "ZT" command.)

"cpg" = Current Proportional Gain, or instantaneous correction.
"cig" = Current Integral Gain, or overall compensation for cumulative errors during the entire weld heat.
"vpg" = Voltage Proportional Gain, used in "voltage mode".
"vig" = Voltage Integral Gain, used in "voltage mode".

The data that follows shows the actual values of these parameters.

METHOD 2: To enter new values in RAM and EEprom.

SYNTAX: "a ZCG cpg cig vpg vig"
"a" = address of WCU
"cpg" = Current Proportional Gain, or instantaneous correction.
"cig" = Current Integral Gain, or overall compensation for cumulative errors during the entire weld heat.
"vpg" = Voltage Proportional Gain, used in "voltage mode".
"vig" = Voltage Integral Gain, used in "voltage mode".

RESPONSE: "ack" or "nak"

ZCM = CHANGE MODE, CURRENT/VOLTAGE

PURPOSE: To enter values into EEprom and RAM for the selection of operating mode of the control. When the control is in the "Current" mode, all "heat" values are entered in secondary amps (x100), and the calculated secondary current value is regulated for heat control. Another parameter is included for transformer size, meaningful when in the "current" mode.
When in voltage mode the "heat" values are in percent (000-100), and the Thyristor output voltage is regulated for heat control. Also in this mode, "window" values are represented as 000-200% of the "heat".

METHOD 1: To recover the values presently in RAM;

SYNTAX: "a ZCM"
"a" = address of WCU

RESPONSE: "m (0 = C: 1 = V), t (0 = <75: 1 = <150: 2 = >150 KVA) = 0,1"
"m" = Mode (0 = Current mode, 1 = Voltage mode.)
"t" = Transformer size (setting should match that of the dip switches on the power board):
"0" is used for transformers smaller than 75 KVA.
"1" is used for transformers 75 KVA to 150 KVA.
"2" is used for transformers larger than 150 KVA.

The data that follows shows the actual values of these parameters.

METHOD 2: To enter new values in RAM and EEprom.

SYNTAX: "a ZCM m t"
"a" = address of WCU
"m" = Mode with 0 = Current mode and 1 = Voltage mode.
"t" = Transformer size (setting must match that of the dip switches on the power board):
"0" is used for transformers smaller than 75 KVA.
"1" is used for transformers 75 KVA to 150 KVA.
"2" is used for transformers larger than 150 KVA.

RESPONSE: "ack" or "nak"

ZCN = CHANGE NEW WINDOW DEFAULT

PURPOSE: To enter values into EEprom and RAM for the default "new window". This is needed for the diagnostics, and these values are used for each heat sequence that does not declare a "New window" with the subcommand "N".

METHOD 1: To recover the values presently in RAM;

SYNTAX: "a ZCN"
"a" = address of WCU

RESPONSE: "nwl, nwh(INITIAL NEW WINDOW %) = 080, 120"
"nwl" = New Window Low value, as a percent of the lowest heat in the sequence.
"nwh" = New Window High, a percent of the highest heat in the sequence.

Note that this would apply to the lowest and the highest heats in the sequence, respectively.

The data that follows shows the actual values of these parameters.

METHOD 2: To enter new values in RAM and EEprom;

SYNTAX: "a ZCN nwl nwh"
"a" = address of WCU
"nwl" = New Window Low value, as a percent of the heat in the sequence.
"nwh" = New Window High, also a percent of the heat in the sequence.

RESPONSE: "ack" or "nak"

ZCO = CHANGE OPERATION VALUES

Purpose: To selsct operation of weld override and slope heat.

METHOD 1: To recover the values presently in RAM;

SYNTAX: "a ZCO"
"a" = address of WCU

RESPONSE: "t(TOTAL OVERRIDE 0 = ON, 1 = OFF), h(HALF CYC INC 0 = ON, 1 = OFF), = 0,1"
"t" = Controls "Total cycles check" for weld override.
0 = Enable total cycles as weld override value.
1 = Weld override based on each heat only.
"h" = Half/Full cycle heat adjustment for slope heats.
0 = Adjust each half cycle, causes imbalance in firing.
1 = Adjust only full cycles, avoids imbalance.

The data that follows shows the actual values of these parameters.

METHOD 2: To enter new values in RAM and EEprom.

SYNTAX: "a ZCO t h"
"a" = address of WCU
"t" = Controls "Total cycles check" for weld override.
0 = Enable total cycles as weld override value.
1 = Weld override based on each heat only.
"h" = Half/Full cycle heat adjustment for slope heats.
0 = Adjust each half cycle, causes imbalance in firing.
1 = Adjust only full cycles, avoids imbalance.

RESPONSE: "ack" or "nak"

ZCP = SCR SHORT LIMITS

PURPOSE: To view and/or change the SCR SHORT detection limits. These values will set up the thresholds for voltage level and amount of time for the SCR short diagnostic.

METHOD 1: To view the present settings of the SCR short.

SYNTAX: "a ZCP"
"a" = address of WCU

RESPONSE: "VOLTAGE LIMIT = vvv, CYCLE LIMIT = cc"
"vvv" = maximum voltage limit level
"cc" = maximum cycle level

METHOD 2: To change the settings of SCR short.

SYNTAX: "a ZCP vvv cc"
"a" = address of WCU
"vvv" = maximum voltage limit level
"cc" = maximum cycle level

RESPONSE: "ack" or "nak"

ZCS = LAST WELD DATA STORAGE SELECTION

PURPOSE: To view and/or change the Data Storage FIFO selection for last weld data. The FIFO is set up to store 100 lines of information. Either the last 100 welds average weld data,, the last 100 welds peak weld data, or the last 100 welds cycle by cycle information (up to a max of 100 cycles). The FIFO is then viewed with the "ZRW" command.

METHOD 1: To view the present setting in the WCU.

SYNTAX: "a ZCS"
"a" = address of WCU

RESPONSE: "0: SINGLE CYCLE INFO."
or "1: CURRENT AND STEPPER INFO."
or "2: WELD SUMMARY INFO."

METHOD 2: To change the setting.

SYNTAX: "a ZCS n"
"a" = address of WCU
"n" = number of selection
0 = Store last weld cycle by cycle.
1 = Store peak information (see "RL") appended with the fault word
2 = Store average information (see "ZRC") appended with the fault word

RESPONSE: "ack" or "nak"

ZCV = CHANGE VOLTAGE CALIBRATION VALUES

PURPOSE: To enter values into EEprom and RAM for voltage calibration.

METHOD 1: To recover the values presently in RAM.

SYNTAX: "a ZCV"
"a" = address of WCU

RESPONSE: "s(0 = ON: 1 = OFF), svt, mvt(V) = 0,440,810"
(Note, this example shows the actual values loaded by the use of the "ZT" command.)
"s" = Switch to turn compensation on, or off for calibration.
"svt" = Set VolTage, set this to actual voltage, measured with a meter.
"mvt" = Measured Value, measured by the control with compensation off.

The data that follows shows the actual values of these parameters.

METHOD 2: To enter new values in RAM;

SYNTAX: "a ZCV s svt mvt"
"a" = address of the WCU
"s" = Switch to turn compensation on, or off for calibration.
"svt" = Set VolTage, set this to actual voltage, measured with a meter.
"mvt" = Measured Value, measured by the control with compensation off.

NOTE: The "mvt" value is obtained by first turning this function off with "aZCV1", then requesting the line voltage with "aZRV". The value returned will be the required "mvt".

RESPONSE: "ack" or "nak"

ZCW = CHANGE RESPONSE WAIT DELAY

PURPOSE: To enter values into EEprom and RAM for any extra delay that a receiving device may require before it can receive the response from a WCU. This may apply to some laptop computers, or systems running an interpretive language. It is generally not required for complied programs or machine language programs.

METHOD 1: To recover the values presently in RAM;

SYNTAX: "a ZCW"
"a" = address of WCU

RESPONSE: "time(RESPONSE DELAY TIME x 0.5 MS) = zzzz"
"zzzz" = The delay time after receiving a message, before "RTS" is turned on by the WCU, and the response follows.

METHOD 2: To enter new values in RAM;

SYNTAX: "a ZCW zzzz"
"a" = address of WCU
"zzzz" = The desired delay x 0.5 Millisec. (i.e. "0004" is 2 Millisecs)

RESPONSE: "ack" or "nak"

ZR = READ MEMORY

PURPOSE: To read the contents of ROM or RAM in the WCU. This will not read the EEprom, however, using the "ZT" command puts the EEprom values in RAM, where they can be read with this command.

METHOD: The WCU address and the memory address & amount to read are included in the command.

SYNTAX: "a ZR yyyy bb"
"a" = address of WCU
"yyyy" = Starting address in memory
"bb" = number of bytes to return. (don't exceed 60, as the maximum message size for WCUs is 128 characters)

RESPONSE OF WCU: (actual example)
Command sent was "a ZR 1294 06"
"2194: 38 A2 0E 3D 5E 91 1C 8D 00" or if the WCU detects a checksum error, it will respond with "nak".

"2194" = The address, echoed back, followed by the data.

ZRC = REQUEST CURRENT INFORMATION

PURPOSE: To read the weld summary data of the last weld.

SYNTAX: "a ZRC"
"a" = address of WCU

RESPONSE: "ccc, hhh, zzzz, pcurA, sc.cKA, vvvV, yyy%, xxx%use"
"ccc" = Number of cycles last welded
"hhh" = Number of cycles monitored (usually 3 less than "ccc")
"zzzz" = Averag value out of the A/D stage
"pcur" = Primary Amps RMS
"sc.c" =Secondary Amps RMS
"vvv" = SCR Output Voltage VAC
"yyy" = Output Voltage in % of nominal bus voltage
"xxx" = Percent use of transformer, 000-100% (amount of available power used)

ZRH = REQUEST HERTZ OF LINE

PURPOSE: To read the line frequency, at the time of the request.

SYNTAX: "a ZRH"
"a" =address of WCU

RESPONSE: "xx.xHZ".
"xx.x" = The frequency of the welding bus in hertz.

ZRV = REQUEST VOLTAGE

PURPOSE: To read the line voltage, at the time of the request.

SYNTAX: "a ZRV"
"a" = address of the WCU

RESPONSE: "vvv"
"vvv" = The line voltage 000V to 999V RMS.

ZRW = READ WELD FIFO INFO

PURPOSE: To read the information stored in the weld data FIFO.

METHOD: Each weld data line, for a maximum of 100, can be read separately or all at the same time. There are instructions for the first line, the next, the previous, or all at once.

SYNTAX:	For the first line:	"a ZRW0"
	For the next line:	"a ZRW"
	For the previous line:	"a ZRW"
	For all lines:	"a ZRWA"

"a" = address of the WCU

RESPONSE:	Lines of cycle by cycle info: "a: b, c, d, e, f, g, h, i, j, k"	
or	Lines of "RL" information with fault word appended.	
or	Lines of "ZRC" information with fault word appended.	

If the "ZCD" command equels "w, x, y, z":
Then the displayed info units will be:

"a" = Line number	(never changes)
"b" = Sample number	(never changes)
"c" = Power factor	(if 'w' = 0 then 1.052d: if 'w' = 1 then 1.0d: if 'w' = 2 then 100* cos)
"d" = Firing angle, lead cycle	(if 'x' = 0 then 1.052d: if 'x' = 1 then 1.0d)
"e" = Firing angle, trail cycle	(if 'x' = 0 then 1.052d: if 'x' = 1 then 1.0d)
"f" = Current off angle, lead	(if 'x' = 0 then 1.052d: if 'x' = 1 then 1.0d)
"g" = Current off angle, trail	(if 'x' = 0 then 1.052d: if 'x' = 1 then 1.0d)
"h" = Proportional gain	(never changes)
"i" = Line voltage	(if 'y' = 0 then A/D: if 'y' = 1 then volts: if 'y' = 2 then %nom) "j"
= Output voltage	(if 'y' = 0 then A/D: if 'y' = 1 then volts: if 'y'= 2 then % nom)
"k" = Heat	(if 'z' = 0 then A/D: if 'z' = 1 then Pri amps: if 'z' = 0 then Sec amps)

The response can be changed by usig the "ZCD" command to indicate the desired type of units. Note that some of these values may become 4 digit, depending on the selection made.

ZSC = SAY COPYRIGHT NOTICE

PURPOSE: To provide the copyright notice, upon request, a legal compliance.

SYNTAX: "a ZSC"

"a" = adress of WCU

RESPONSE: "(C) Copyright 1987 by Toshiba corporation all right reserved ehc"

ZSN = SAY NAME & REVISION DATE

PURPOSE: To provide the revision level of the currency installed software in the WCU

SYNTAX: "a ZCN"

"a" = adress of WCU

RESPONSE: "PROGRAM NAME 7513, VERSION:E01, DATE: FEBRUARY 21, 1991"

This information may change from time to time as software upgrades take place.

ZSW = SAY WHAT FAULTED IN ENGLISH

PURPOSE: To indicate any faults, in a convenient format.

SYNTAX: "A ZSW"

RESPONSE: A message will be returned, stating what fault(s) are currently active. The message contains the fault bit number also, such as;

"<BIT 3> THYRISTOR SHORT CIRCUIT DETECTION"

ZT = TRANSFER INITIALIZATION PARAMETERS

PURPOSE: To allow initialization of parameters to the factory set point, for WCU start-up. This also initializes all calibration values in the EE-prom, and will be automatically transferred into the Ram upon power-up, if this function is not called.

SYNTAX: "a ZT"

"a" = address of the WCU

RESPONSE: "ack" or "nak"

The following settings in the WCU are reset by "ZT" command, so they are the same as issuing the following commands:

a ZCC 0 0620 100 200 106 203

a ZCD 00

a ZCG 128 128 128 128

a ZCN 080 120

a ZCO 0 1

a ZCW 0500

aZCV 0 480 780

It is important to note that the communication response delay is changed to 250 milliseconds, which may appear to cause loss of communications for the device that is waiting for the response. this will occur if the device "times out" in less than 250 ms, waiting for the response. To prevent problems with this it is recommended that the "a ZT" command be immediately followed by the command "aZCW0004", which sets the response delay to two milliseconds. (Or use this to set the delay to the value appropriate to the interface device.)

In the case of a slow interface, that cannot accept a response within a few milliseconds after the command, this "ZT" command will appear to restore the responses, beacause it causes the long delay typically required of a compute running interprester program, such as "BASIC" (Beginner´s Allpurpose Symbolic Instruction Code).

ZW = WRITE MEMORY

PURPOSE: To write values directly in memory. This will nor work for EEprom values, as only the transfer (ZTE) command can do this. Also it will not change the program in Eprom, or Rom. There is a write enable parameter on the Eprom that can disallow this function, for data security considerations

¤¤¤¤¤¤¤¤USE EXTREME CAUTION WITH THIS COMMAND¤¤¤¤¤¤¤¤

METHOD: The address of the WCU and the address of memory are in the command, along with the data to be written.

SYNTAX: "a ZW adrs bb cc dd...zz" Max 128 characters.

"a" = address of WCU
"adrs" = starting write address
"bb", "cc",... = data to be written starting at "adrs"

RESPONSE: If the WCU detects a checksum error, it will respond with "nak". Otherwise, it will echo back the changes to memory, as entered with this command.

EXPLANATION OF FAULTS

GENERAL INFORMATION

There are two (2) types of faults:

1. Operation faults: Occur when the WCU is performing a sequence or monitoring for problems in operation.

The operation faults that occur are stored in the "operation fault word", and can be covered with instruction 'W', for `What faulted?´.

2. Communication faults: Occur when data is not receiced with the correct checksum. The communication faults are reported back to the data entry device as NAK code. Also bit 2 in the fault word gets set.

The following chart shows the meaning of each bit in the fault word.

CHART #1: THE OPERATION FAULT WORD

BIT 0 = Undercurrent detection and announcement
BIT 1 = Overcurrent and shutdown
BIT 2 = Communication (checksum) error
BIT 3 = IN UNMASK WORD: SET = Faults clear on next initiation
= IN FAULT WORD: SET = Thyristor short detection and shunt trip
BIT 4 = (reserved)
BIT 5 = Failed to fire detection and shutdown on 3rd cycle
BIT 6 = Overtemp detection and shutdown
BIT 7 = End of stepper detection and shutdown
BIT 8 = Illegal sequence was selected
BIT 9 = Tip sensing initiation canceled after 5 seconds
BIT10 = Loss of 50/60 Hz reference (welding bus) detection and shutdown
BIT11 = Memory error detection and shutdown
BIT12 = Weld override detection and shutdown
BIT13 = Power factor out of range detection and shutdown
BIT14 = Current out of range detection and announcement
BIT15 = Data requested has not been programmed
BIT16 = Current pickup set to low
BIT17 = Current pickup set to high
BIT 18 = Directory memory error
BIT 19 = Schedule illegal format detected
BIT20 = Stepper program memory error
BIT21 = Operating parameter memory error
BIT22 = Unmask word memory error
BIT23 = Parameter memory error
BIT24 = Frequency out of range
BIT25 = Failed "U" command
BIT26 = Current calibration error
BIT27 = Emergency fault detected
BIT 28-31 (reserved)

BIT 0: UNDERCURRENT OR UNDERVOLTAGE DETECTION

CAUSE:
The WCU encounters a condition in which the weld current (if in creg) or the output voltage (if in vreg) falls below the low limits set in either the operating parameters or in the "New Window" command.

WCU ACTION:
1. Bit 0 in the fault word gets set.
2. Weld is aborted.

POSSIBLE CAUSES:
1. Firing the weld before the weld gun is closed
2. Poor part fit
3. A foieign substance buildup on the weld tips.
4. Loose secondary wiring on the transformer.
5. Opening of the welding contactor during welding.
6. Improper setup of the "Window Limits" in the "O" or "ZCN" commands or the "N" subcom.
7. Improper setup of the switches on the power board.
8. Improper setup of the "Transformer Size" in the "ZCM" command.
9. Improper setup of the transformer turns ratio with the "O" command or "R" subcommand.
10. Bad Power board.
11. Bad CPU board.

BIT 1: OVERCURRENT OR OVERVOLTAGE DETECTION

CAUSE:
The WCU encounters a condition in which the weld current (if in creg) or the output voltage (if in vreg) rises above the limits set in either the operating parameters or in the "New Window" sub-command.

ACTION TAKEN:
1. Bit 1 of the fault word gets set.
2. Weld is aborted.

PROBABLE CAUSES:
1. Improper setup of the buss voltage value in the Operating Parameters.
2. Poor part fit causing arcing.
3. Improper voltage calibration performed.

BIT 2: COMMUNICATION ERROR

CAUSES:
1. If a command is unfinished before another starts.
2. When the "horizontal parity check" does not match the data sent.

ACTION TAKEN
1. Fault word bit 2 is set.
2. The announcement "NAK" is returned by the WCU the data was being sent to.

PROBABLE CAUSES:
1. Noisy communication line.
2. Improper operation of the host.
3. Bad CPU board.

BIT 3: CLEAR FAULTS ON INITIATION/SCR SHORTED INDICATION

This bit serves two functions:
(1) Reserved for the fault Unmask word, when set, causes the fault to clear with each new initiation. If off, the fault do not clear until the fault reset is sent to the WCU.
(2) When set in the fault word, it indicates that a shorted Thyristor was detected, which also causes shunt trip of the common circuit breaker.

CAUSE (for 2 above)
The WCU has detected an output voltage on the SCR that is above the threshold set with the "ZCP" command at a time when there should have been no output.

ACTION TAKEN:
1. Fault word bit 3 is set.
2. Shunt trip circuit is open.
3. Weld is aborted.

PROBABLE CAUSES:
1. Open primary wiring to the welding transformer.
2. Short detection threshold set to low with the "ZCP" command.
3. Opening the welding contactor during welding.
4. Bad CPU board
5. Bad power board.

BIT 4: RESERVED FOR FUTURE APPLICATIONS

BIT 5: SCR FAILED TO FIRE

CAUSE:
The CPU did not detect any current flow out of the SCR when it told it to fire.

ACTION TAKEN:
1. Bit 5 in the fault word gets set.
2. Weld aborted on the third half cycle.

PROBABLE CAUSES:
1. Bad connection between the power board and the SCR (check trigger wires)
2. Bad power board.
3. Bad CPU board.
4. Bad SCR

BIT 6: OVERTEMP DETECTION

CAUSE:
Whenever the overtemp circuit opens. The SCR thermistat is set at 55 degC.

ACTION TAKEN:
1. Bit 6 of the fault word gets set.
2. Stops firing.

PROBABLE CAUSES:
1. Open external overtemp circuit (check jumper in TB1).
2. Poor cooling conditions. Check temp and flow rate.
3. Bad SCR thermistat.

BIT 7: END OF STEPPER DETECTION

CAUSE:
When the final stepper count is reached for any stepper used by a sequence.

ACTION TAKEN:
1. Bit 7 of the fault word gets set.
2. The control is halted when initiated on any schedules using that stepper.

PRABABLE CAUSES:
1. Weld count has reached the ending value in the stepper.
2. Stepper not properly set up.
3. A stepper was called on to increment that was not programmed.

BIT 8: ILLEGAL SEQUENCE SELECTED

CAUSE:
A sequence or stepper that is not available (other than 0 thru F hex) was requested or attempted to be programmed.

ACTION TAKEN:
1. Bit 8 of the fault word gets set.

PROBABLE CAUSES:
1. An attempt to program an unalowed schedule or stepper was made.
2. Bad CPU board.

BIT 9: TIP SENSING TIMED OUT

CAUSE:
Tip sensing initiation was used and 5 seconds have elapsed without sensing tip closed.

ACTION TAKEN:
1. Bit 9 of the fault word gets set.
2. The sequense is aborted.

PROBABLE CAUSES:
1. Gun did not close within the timeout.
2. Poor part fit.
3. Bad wiring on the secondary of the welding transformer.
4. Bad power board.
5. Bad CPU board.

BIT 10: LOSS OF REFERENCE (BUS VOLTAGE)

CAUSE:
Reference signal of the AC line cannot be sensed. This is a normal rest condition of many tools which open thier contactors after welding.

ACTION TAKEN:
1. Bit 10 of the fault word gets set.
2. The control halts all firing pulses, and cannot be initiated.
3. Will reset automatically when the voltage is reapplied.

PROBABLY CAUSES:
1. Isolation contactor not closing properly.
2. Main breaker is tripped.
3. Improper wiring to the WCU power section.
4. SCR shortthresholds set too high (above the bus voltage) with the "ZCP" command.
5. Improper voltage calibration performed.
6. Bad power board.
7. Bad CPU board.

BIT 11: MEMORY ERROR

CAUSES:
1. RAM memory is scrambled in certain "check" locations.
2. Instructions stored in WCU are in error.
3. EProm checksum does nor match.

ACTION TAKEN:
1. Bit 11 of the fault word gets set.
2. The control is disabled, will not initiate.

PROBABLE CAUSES:
1. CPU power was removed from the ROTWEL-MAX1 for an extended period of time. At least two to three weeks.
2. Extremely noisy environment.
3. Bad CPU board.

BIT 12: WELD OVERRIDE DETECTION AND SHUTDOWN

CAUSES.
Cycles in a shedule heat command exceed the maximum allowed in the operating parameters.

ACTION TAKEN:
1. Bit 12 of the fault word gets set.
If "un-mask" bit 12 is on, add the following:
2. Any current cycles entered over the maximum allowed cycles (setup in the operatin parameters), is automatically limited to the max allowed value, therefore no errors occurs. The WCU continues on to perform the rest of the sequence.

PROBABLE CAUSES:
1. Cycles of heat programmed exceeded the maximum allowed in the operating parameters.

BIT 13: POWER FACTOR OUT OF RANGE

CAUSE:
A power factor limit window in a sequence was exceeded.

ACTION TAKEN:
1. Bit 13 in the fault word gets set.
2. The control is disabled, will not initiate.

PROBABLE CAUSES:
1. Power factor window not set up properly.
2. Secondary of the transformer is degrading in quality (shunts, tips, loop area,...)
3. Guns were open when the WCU was initiated.
4. Secondary loop not a complete circuit.
5. Bad power board.
6. Bad CPU board.

BIT 14: CURRENT OUT OF RANGE

CAUSE:
The current window in the "operating parameter download" instruction has been exceeded. Note that exceeding the high limit is not allowed at any time, the low limit is checked only at the end of the sequence.

ACTION TAKEN:
1. Bit 14 ofthe fault word gets set.
2. The control limits firing on an over current because of the constant current feature.

PROBABLE CAUSES:
1. The current window in the operating parameters not set up properly.
2. The heat requested in a weld schedule was above the limits set in the operating parameters.
3. Bad CPU board.

BIT 15: SCHEDULE OR STEPPER DOES NOT EXIST

CAUSE:
1. Initiating the WCU on a schedule that not has been programmed.
2. Calling a stepper to be incremented that does not have data.
3. Requesting the data from a schedule or stepper that has not been programmed.

ACTION TAKEN:
1. Bit 15 of the fault mask word gets set.
2. Bit 25 of the fault mask word gets set if 1 or 2 above.

PROBABLE CAUSES:
1. Invalid entry made for schedule or stepper selection.
2. Inproper operation of the host.
3. Bad CPU board.

BIT 16: CURRENT FEEDBACK TOO LOW

CAUSE:
The current feedback signal is too small.

ACTION TAKEN:
1. Bit 16 of the fault mask word gets set.
2. Weld is aborted.

PROBABLE CAUSES:
1. Secondary not drawing current (open circuit).
2. The transformer is too small of a load (below 5 kVA).
3. The 2 position DIP switch in the WCU for the transformer size is set too high.
4. The transformer size selection in the "ZOM" command is set incorrectly.
5. The current pickup is malfunctioning.

BIT 17: CURRENT FEEDBACK TOO HIGH

CAUSE:

The current feedback signal is too high.

ACTION TAKEN:
1. Bit 17 of the fault mask word gets set.
2. Weld is aborted.

PROBABLE CAUSES:
1. Switches set up improperly on the WCU:s power board.
2. Transformer size selection incorrect with the "ZOM" command.
3. Transformer tap swith set too high.
4. Bad power board.
5. Bad CPU board.

BIT 18: DIRECTORY MEMORY ERROR

CAUSE:
The checksum stored with the directory in the RAM memory does not match the data of the directory.

ACTION TAKEN:
1. Bit 18 of the fault mask word gets set.

PROBABLE CAUSES:
1. Extremely noisy environment and /or bad line filtering.
2. Power removed from the WCU for more than 2-3 weeks.
3. Bad CPU board.

BIT 19: SCHEDULE ILLEGAL FORMAT DETECTED

CAUSE:
The schedule data stored in the WCU was found to be of incorrect syntax when initiated.

ACTION TAKEN:
Bit 19 of the fault mask word gets set.

PROBABLE CAUSES:
1. Schedule was not downloaded correctly to the weld control.
2. Power removed from the Rotwel-Max1 for more than 2-3 weeks.
3. Bad CPU board.

BIT 20: STEPPER PROGRAM MEMORY ERROR

CAUSE:
The stepper checksum and the stepper data do not match.

ACTION TAKEN:
Bit 20 of the fault mask word gets set.

PROBABLE CAUSES:
1. Extremely noisy environment and/or bad line filtering.
2. Power removed from the Rotwel-Max1 for more than 2-3 weeks.
3. Bad CPU board.

BIT 21: OPERATION PARAMETER MEMORY ERROR

CAUSE:
The operation parameter checksum dos not match the data.

ACTION TAKEN:
1. Bit 21 of the fault mask word gets set.

PROBABLE CAUSES:
1. Extremely noisy environment and/or bad line filtering.
2. Power removed from the Rotwel-Max1 for more than 2-3 weeks.
3. Bad CPU board.

BIT 22: UNMASK WORD MEMORY ERROR

CAUSE:
The unmask word and its checksum do not match.

ACTION TAKEN:
Bit 22 of the fault mask word gets set.

PROBABLE CAUSES:
1. Extremely noisy environment and/or bad line filtering.
2. Power removed from the Rotwel-Max1 for more than 2-3 weeks.
3. Bad CPU board.

BIT 23: PARAMETER MEMORY ERROR

CAUSE:
The parameter data and checksum do not match.

ACTION TAKEN:
1.Bit 23 of the fault mask word gets set.

PROBABLE CAUSES:
1. Extremely noisy environment and/or bad line filtering.
2. Power removed from the Rotwel-Max1 for more than 2-3 weeks.
3. Bad CPU board.

BIT 24: FREQUENCY OUT OF RANGE

CAUSE:
The line frequency is not within 48-52 or 58-62 Hertz.

ACTION TAKEN:
1. Bit 24 of the fault mask word gets set.
2. Weld is aborted.

PROBABLE ACUSES:
1. Extremelynoisy environment and/or bad line filtering.
2. Unstable power generator.
3. Bad CPU board.

BIT 25: FAILED "U" COMMAND

CAUSE:
The sequence referenced in the "U" command has an error or conflict with the operating parameters. This could be also caused by initiating a sequence that calls for a current that is outside of the range for primary amps in the operating paramets or initiating a sequence that dos not exist. Generally, any time something is "used" that causes an error.

ACTION TAKEN:
1. Bit 25 of the fault mask word gets set.
2. Weld is aborted.

PROBABLE CAUSES:
1. This bit will get set align with another bit describing the problem.
2. Bad CPU board.

BIT 26: CURRENT CALIBRATION ERROR

CAUSE: (wrong values in the current calibration command)
1. Winding ratio is set to less than 1.0
2. Current setting (low) is equal to or greater than current setting (high).
3. Current measured (low) is equal to or greater than current measured (high).

ACTION TAKEN:
1. Bit 26 of the fault mask word gets set.
2. Bit 25 of the fault mask word gets set.

PROBABLE CAUSES:
1. Improper values entered while in the current calibration mode.
2. Calibration process aborted before completion.
3. Bad CPU board.

BIT 27: EMERGENCY STOP DETECTED

CAUSE:
The weld control has detected a loss in the 24 VAc emergency stop input.

ACTION TAKEN:
1. The emergency stop for the fixsture has been hit.
2. Power source problem supplying the 24VAc.
3. Bad connection on TB1.
4. Bad power board.
5. Bad CPU board.