AUSGABEN:

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Operating instructions for

LOCOMOTIVE DECODERS MX60/N and MX61/N

with green marking on the resonator

with red marking on the resonator

for DCC systems conforming to NMRA standards

also in version MX60R/N resp. MX61R/N (with NMRA plug - medium interface)

CONTENTS :

1. Introduction

The decoders MX60/N and MX61/N are intended for installation in small scale locomotives (H0). They comply with the NMRA standardized DCC protocol. Therefore they can be used both with ZIMO DCC systems and with DCC systems from manufacturers like Lenz Roco ("digital is cool"), LGB, Digitrax, etc.

MX60/N	***Low-priced*** loco decoder for all usual D.C. and A.C. motors up to 0,8 A maximum current (no back EMF, not suitable for Faulhaber); 3 amplified function outputs (200 mA each) and 3 logical function outputs (only to use with external amplification).
MX61/N	As MX60 (identical dimensions, identical functions), but with ***back EMF control***. Also suitable for Faulhaber and other coreless motors.
MX60R/N	Version of MX60 with interface plug according to NMRA RP-9.1.1 (medium).
MX61R/N	Version of MX61 with interface plug according to NMRA RP-9.1.1 (medium).

NOTE: For smaller scales (N, H0e) a miniaturized version of the MX61, the ***"MX62"*** is under development (as of 1997, december).

2. Specifications

The whole decoder circuitry is placed on a multilayer printed circuit board. It is protected against unintentional contacting by a transparent shrinking cover. Highly flexible wires are used for connecting to rails, motor and functions. For the three logical function outputs and some auxilliary connections soldering pads are provided.

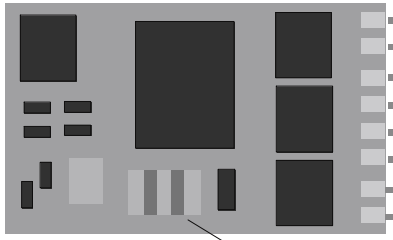
Track voltage ..... 10 - 24 V
Motor output - short-time current (5 sec) ..... 2 A
- continuous current ..... 0,8 A
Headlight current ..... 0,2 A
Third function output current ..... 0,2 A
Decoder max. current ..... 1 A
Logical function outputs externally amplified with M4000Z ..... 0,5 A
Operating temperature ..... - 20 bis 100 °C
Dimensions ..... 25 x 16 x 4,5 mm
Lenght of connecting wires at MX60/N, MX61/N .....120 mm
Lenght of connecting wires to interface plug of MX60R, MX61R ..... 60 mm .

OVERLOAD PROTECTION:

The decoder outputs are protected against short-circuit and high current on . After detection of an overload condition the output is swichted off for some seconds until the reason is removed (periodic attempts for switching on are done automatically).

NOTE: The overload protection does not mean decoders are indestructible. In particular incorrect connection to rails and motor or a faulty motor could cause damage to the decoder.

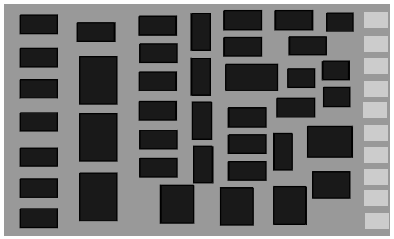
MX60 / MX61 Top view



		ZIMO cab	NMRA function
white	Front headlight(s)	1 (L)	F0
brown	Third function output	2 (LL)	F1
yellow	Rear headlight(s)	1 (L)	F0
gray	Left-hand motor brush		
orange	Right-hand motor brush		
blue	Common headlights and functions power sou		
black	Left-hand rail power pick-up		
red	Right-hand rail power pick-up		

Resonator: green marking means, that this decoder is a MX60; red marking means MX61.

MX60 / MX61 Bottom view



Vdd
MCLR
RB7
RB6
Direction bit

Not for use in normal decoder operation ! These pads are provided only for production of the decoder (software loading).

Third function output (logical)
GROUND
ZIMO key 5 (Z2); NMRA function F4
ZIMO key 4 (Z1); NMRA function F3

ATTENTION: Logical outputs ! No direct connection to load allowed. Only use with external amplification module M4000.

3. Addressing and programming

For DCC operation each locomotive (i.e. decoder installed) must have an address for being able to control it from the cab or from the computer. New ZIMO decoders have address 3 (MX60, MX61) or address 5 (MX60R, MX61R); a note in the decoder box indicates the actual address.

PREPRARING FOR ADDRESSING AND PROGRAMMING:

After installation into the loco (details in chapter 4) the loco can be tested on address 3 resp. 5. For successful addressing and programming either motor or headlights (better: both) must be connected to the decoder. It makes sense to make the full installation (all lights, smoke generator, etc.) before starting addressing and programming.

PROCEDURE FOR ADDRESSING AND PROGRAMMING:

Addressing and programming (the "configuration variables) is done either from the cab of the Digital Command system (ZIMO system: MX2 cab) or from the computer (ZIMO Software P.F.u.Sch.). Details of the operating procedure are included in the manuals of the system or of the software !

The ZIMO decoders accept both ***direct programming*** (used by ZIMO, Lenz, Digitrax "Chief", and others) and ***paged programming*** (used by Digitrax "Big boy", Winlok, and others). Also ***register programming*** (for CVs 1 - 8) can be done.

THE CONFIGURATION VARIABLES:

Configuration variables ("CV"s) allow the decoder to be customized for each locomotive; they are stored in non-volatile memory and do not change when power is removed from the decoder.

The meaning of the most variables is defined in NMRA RECOMMENDED PRACTICES RP-9.2.2; some CVs are ZIMO specific (in the NMRA reserved manufacturer use sector # 49 - # 60).

Although most CVs are NMRA defined, you must look to the following specification of each variable, because for example the allowed values is different from manufacturer to manufacturer.

CV Number	Name	Range	Default *)	Description
# 1	**Primary address**	1 - 127	3, 5	The "short" loco address; it is active, when Bit 5 in CV # 29 (configuration data) = 0 (otherwise extended address is active).
# 2	**V_{start}**	1 - 252	7	This value defines the internal speed step (~ voltage drive level) used for the first (lowest) external speed step. Only effective, when Bit 4 in CV # 29 = 0 (this means speed table by CVs # 2, 5, 6).
# 3	**Acceleration rate**	0 - 255	0	Determines the decoder´s accelaration rate. Multiplied with 0.9 it gives the time in sec from stop to full speed.
# 4	**Deceleration rate**	0 - 255	0	Determines the decoder´s decelaration rate. Multiplied with 0.9 it gives the time in sec from full speed to stop.
# 5	**V_{high}**	1 - 252	252	This value defines the internal speed step (~ voltage drive level) used for the highest external speed step (which is 14, 28 or 126, dependent on used speed step mode). Only effective, when Bit 4 in CV # 29 = 0 (this means speed table by CVs # 2, 5, 6).
# 6	**V_{mid}**	1 - 252	0	This value defines the internal speed step (~ voltage drive level) used for the middle external speed step (which is 7, 14 or 63, dependent on used speed step mode 14, 28 or 128). The default value "0" means automatic assignement of 1/3 of value in CV # 5 (Vhigh). Only effective, when Bit 4 in CV # 29 = 0 (this means speed table is defined by CVs # 2, 5, 6).
# 7	**Manufacturer version No.**	no write access		Information regarding the version of the decoder.
# 8	**Manufacturer ID**	no write access		NMRA assigned id number of the manufacturer of this decoder. ZIMO has decimal value "145" ("10010001").

Continued on next page !

*) ***"Default"*** means the value of the CV at delivery of the decoder or after "Hard reset" (done by addressing to "0" (zero) - details in operating manual MX2 !

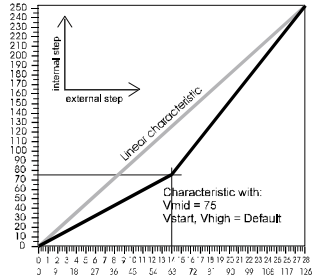
CV Number	Name	Range	Default *)	Description
# 9	**Total PWM period**	255 -176, 0	208	PWM period (in us) according to formela (131+ mantisse*4)*2^{exp} Bit 0-4 is "mantisse", Bit 5-7 is "exp". Motor frequency is the reci procal of the PWM period. EXAMPLES : # 9 = 255: Motor frequency 30 Hz, # 9 = 223: Motor frequency 60 Hz, # 9 = 208: Motor frequency 80 Hz, # 9 = 192: Motor frequency 120 Hz, # 9 = 0: Motor frequency **16 kHz**.
#17+18	**Extended address**	128 - 10139	0	The "long" **loco address**, alternatively to address in # 1; this is active, when Bit 5 in CV # 29 (configuration data) = 1.
# 19	**Consist address**	0 - 127	0	Contains an address which is used to control locomotives in consist. If there is a value unequal "0", speed and direction is controlled by the consist address. Function outputs are controlled by primary or extended address also in this mode.
# 29	**Configuration data** Calculation for CV # 29 is done by addition of bit values : Bit = 0, = 1 Bit 0: value 0 or 1 Bit 1: value 0 or 2 Bit 2: value 0 or 4 Bit 3: value 0 or 8 Bit 4: value 0 or 16 Bit 5: value 0 or 32 Bit 6: value 0 or 64 Bit 7: value 0 or 128	0 - 63	2	Bit 0 - Locomotive direction: 0 = normal, 1 = reversed Bit 1 - Speed steps and FL location: 0 = 14, 1 = 28 speed steps (Note: the instructions for 128 speed steps are accepted always, independent of this bit.) Bit 2 - Power source conversion: 0 = Digital operation only 1 = Conversion enabled Bit 4 - Speed characteristic: 0 = defined by CVs # 2,5,6, 1 = speed table defined by CV # 67 - 94 Bit 5 - Loco address:: 0 = Primary address CV # 1, 1 = Extended address CV 17+18 Bits 3, 6, 7 always "0" (zero) ! EXAMPLES: # 29 = 2: normal direction, 28 speed steps, digital operation only, speed table by CVs # 2,5,6. address in CV # 1 (1 - 127).
				# 29 = 6: as above, but with power source conversion. # 29 = 22: as above, but with power source conversion and speed table defined by CVs # 67 - 94. # 29 = 0: 14 (instead 28) speed steps; this is the typical value for use in old Lenz systems or ROCO´s "digita is cool".
# 33 **# 34** **# 35** **# 36**	**Output locations**	0,1,2,4	0	This is a partial version of the NMRA "funcion mapping" (CVs # 33 - 42). # 35 - 36 = 0: The default value means, that headlights are direction dependant and can be switched on/off by key "1" key (NMRA function F0).
# 49	**Signal controlled acceleration**	0 - 255	0	**Only relevant in case decoder is used within ZIMO system.** The value of this CV, multiplied with 0.4, gives the time in secs from signal controlled stop to full speed.
# 50	**Signal controlled deceleration**	0 - 255	0	Only relevant in case decoder is used within ZIMO system. The value of this CV, multiplied with 0.4, gives the time in secs from full speed to signal controlled stop.
#51-55	**Signal controlled speed limits**	0 - 252	20, 40, 70, 110, 180	**Only relevant in case decoder is used within ZIMO system.** ZIMO HLU- and track section modules apply signal controlled speed limits in 5 steps. The values in CVs # 51 - 55 define the internal speed step (~ voltage drive level) for each of the speed limits.
MX61: **# 56**	**Back EMF control D-parameter**	0 - 255	50	Back EMF load compensation control is done by a PID (Proportional-Integral-Differential) algorithm. The parameters (weighting) for proportional control is defined by CV # 61, and for the differential control by CV # 56. Higher than default values sometimes improve slow speed motion, lower values middle speed

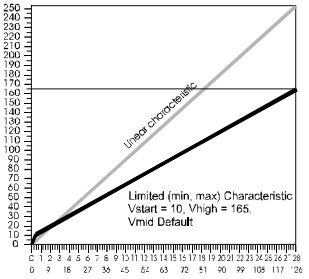
✓ Number	Name	Range	Default *)	Description
MX61: ♯ **57**	**Voltage reference**	0 - 255	0	Divided by 10, this CV gives the absolute voltage drive level, which should be apllied on full speed. Use of this CV can be useful, if the power station does not stabilize the tracks voltage; so it is not necessary within ZIMO system. # 57 = 0: in this case (should be preferred) the absolute voltage drive level follows automatically the track.
MX61: ♯ **58**	**Back EMF intensity**	0 - 255	255	Intensity of load compensation by back EMF control. Sometimes partial load compensation is better than full compensation, e.g. in consists or for more prototypical way of operation. EXAMPLES: # 58 = 0: no compensation (MX61 as MX60), # 58 = 150: partial compensation, # 58 = 255: full compensation.
♯ **59**	**Signal controlled reaction time**	0 - 255	0	**Only relevant in case decoder is used within ZIMO system.** Multiplied with 10, this CV gives the time in secs for starting a signal controlled acceleration after reception of a higher than actual speed limit (or full).
♯ **60**	**Function outputs voltage reduction**	0 - 255	0	The effective voltage on the function outputs can be reduced by PWM operation. This allows use of low voltage bulbs (e.g. 12 V at 20 V track voltage), improves lifetime and reduces brightness. EXAMPLES: # 60 = 0 or 255: full voltage # 60 = 180: 70 % of track voltage
MX61: ♯ **61**	**Back EMF control P-parameter**	0 - 255	40	Back EMF load compensation control is done by a PID (Proportional-Integral-Differential) algorithm. The parameters (weighting) for proportional control is defined by CV # 61, and for the differential control by CV # 56. Higher than default values sometimes improve slow speed motion, lower values middle speed.
♯**67-94**	**Individual speed table**	0 - 252	4,7,10 13,16, 20,24, 28,32, etc.	Internal speed steps for each of the 28 external speed steps (interpolation when using 128 external speed steps). Only effective, when Bit 4 in CV # 29 =10 (this means speed table by CVs # 67 - 94).

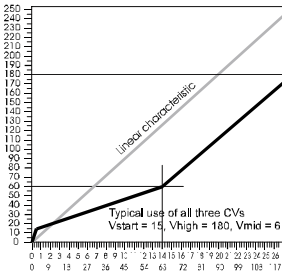
REMARKS TO SPEED CHARACTERISTIC:

For optimizing the operating characteristic the speed table to be used by the decoder can be programmed in two different ways:

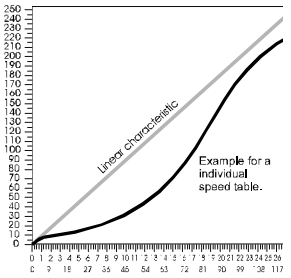
By 3 configuration variables (CVs # 2, 5, 6 for V_{start}, V_{high}, V_{mid}) - This is a simple but efficient way, easy to do from the cab of the DCC system. It is active, when ***Bit 4 in CV # 29 = 0*** (Default).







By 28 configuration variables (CVs # 67 - 94) - One internal speed step is assigned to each of the 28 external speed steps; if 128 external speed steps are used, an interpolation algorithm is used for the steps between. This is the most flexible way for defining the motor characteristic, but it needs 28 programming steps. Therefore it is more comfortable to do it from the computer (e.g. ZIMO Software P.f.uSch. or Winlok). It is active, when ***Bit 4 in CV # 29 = 1***.



**) Default values for CVs # 67 - 94:
4,7,10,13,16,20,24,28,32,36,42,48,54,60,68,76,84, 92,102,112,124,136,152,168,188,208,230,252

REMARKS TO MOTOR DRIVING FREQUENCY:

The ***configuration variable # 9*** defines the motor driving frequency. The low range (30 bis 150 Hz) is the usual way of digital command control systems; the high frequency (***CV # 9 = 0*** makes ***16 kHz***) is a ***noiseless way*** of driving a motor. This is optimal for motors like Faulhaber and other coreless motors; it is recommended by manufactures of the motors. The 16 kHz operation is also useable for the most locos manufactured recently.

The NMRA "function mapping"

The configuration variables # 33 - 36 belong to the fuction keys of the cab; each bit belongs to a certain function output of teh decoder. By setting bits each key can be assigned to a output.

NMRA function	CV	Function key of the ZIMO cab	Logical function outputs					Amplified function outputs		
				Z3	Z2	Z1		"Third" function	Head rear	Head front
F0	# 33	1 (L) forw.	(7)	(6)	5	4	(3)	2	1	0 ●
F0	# 34	1 (L) backw.	(7)	(6)	5	4	(3)	2	1 ●	0
F1	# 35	2 (LL)	(7)	(6)	5	4	(3)	2 ●	1	0
F2	# 36	3 (Z)	(7)	(6)	5	4	(3)	2	1	0
F3	fixed!	4 (Z1)				●				
F4		5 (Z2)			●					

The table above shows the default setting; the headlights can be switched on/ off by "1" key (NMRA function F0); The "third function output" is switched on and off by "2" key (NMRA function F1). For this setting all configuration variables cotain "0" (default values for the new decoder) or - with the same meaning - CV # 33 = 1; # 34 = 2; # 35 = 4.

NOTE: Teh 3 logical function outputs are assigned invariable to the keys "4" to "6" (NMRA functions F3, F4, F5), but the outputs Z1 and Z2 can be assigned additonally to other keys..

F0	# 33	1 (L) forw.	(7)	6	5	4	(3)	2	1	0 ●
F0	# 34	1 (L) backw.	(7)	6	5	4	(3)	2	1	0 ●
F1	# 35	2 (LL)	(7)	6	5	4	(3)	2	1 ●	0
F2	# 36	3 (Z)	(7)	6	5	4	(3)	2 ●	1	0

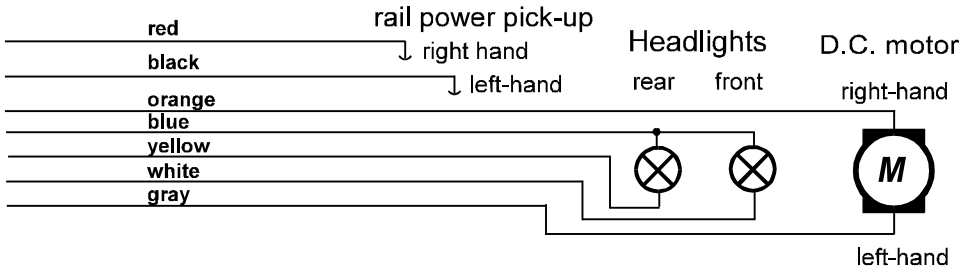
EXAMPLE (above): The headlights should be operated separatly by the keys "1" and "2" (NMRA functions F0 and F1); the third function output should be operated by "3" (NMRA function F2). The following has to be programmed into the configurion variables:

CV # 33 = 1; # 34 = 1; # 35 = 2; CV # 36 = 4.

4. Decoder installation and wiring

. . . in a D.C. locomotive (motor and headlights):

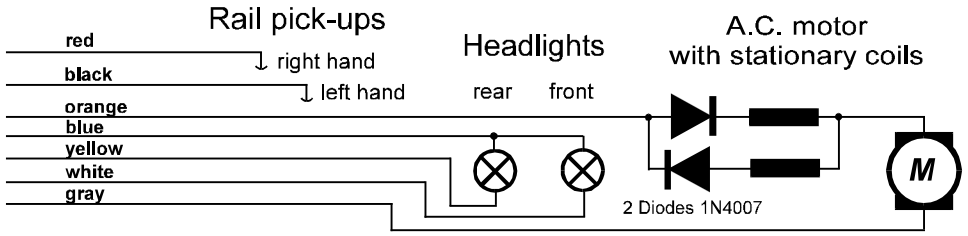
The following schema is the most frequent application for MX60 / MX61. If the loco has the standardized NMRA interface (medium), MX60R / MX61R is used instead; also in this case the schema is valid.



NOTE:
If one pole of the headlights is connected to the chassis of the locomotive (and on this way to one of the rail pick-ups) and cannot be disconnected, the second pole of the headlights is connected to the white resp. yellow wire of the decoder on the same way as above and the blue wire remains unused. The headlights are working in this case with reduced brightness.

. . . in a A.C. locomotive:

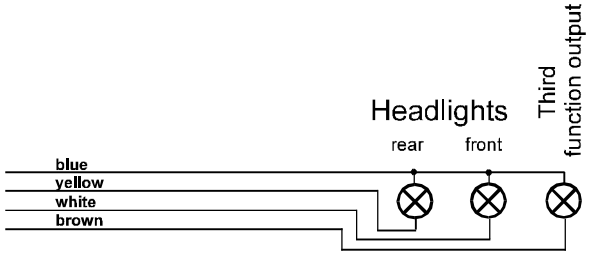
Baiscally the same as for D.C. locos. But the A.C. motor has 3 poles to connect; two rectifiers (diodes) are necessary to connect the motor and make it to follow the direction set by the cab.



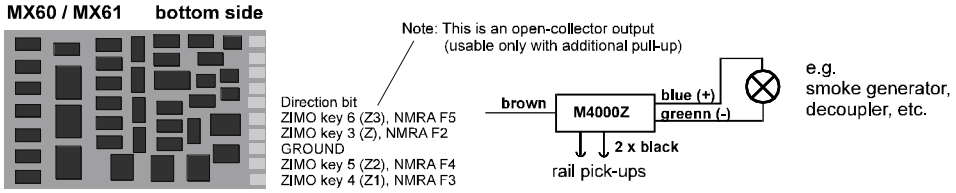
. . . use of the third function output:

The third function output (brown wire) is used in the same way as the headlight outputs; e.g. for a smoke generator or for an additional bulb.

NOTE:
You must bear in mind the maximum current of 200 mA on the function outputs. If this is not sufficient, then a logical output on the bottom side of the decoder could be used together with an external amplification module for the same function key (“2" (LL) on ZIMO cabs, F1 on Lenz and Digitrax).



. . . use of the logical function outputs (bottom side of the decoder):



The decoder MX60 / MX61 has 5 soldering pads on its bottom side for additional function outputs (including the direction bit). These are “logical outputs”; that means: no direct connection of any equipment is allowed.

The only allowed use of these function outputs is the connection to inputs (brown wires) of ***external amplification modules M4000Z***. Up to 5 M4000Z modules could be used with one decoder (one for each logical output).

Each M4000Z has its own wires (black) to rail power pick-ups and its output (blue, grenn wires) is able to drive lightnings, smoke geneerators, decouplers, etc. up to 500 mA.

Special note for logical output “Z3" (NMRA function F5): There are two restriczions using this output:
- Only with an additional pull-up-resistor (e.g. 10K to the blue wire) operable !
- If used within ZIMO systems: Switch-on, switch-off only if ”MAN" is on (this is only true for decoders with serial numbers ~> 55200).

5. Use of MX60/N or MX61/N in various DCC systems

The ZIMO decoders comply to NMRA standards and recommended practices. Anyway, different systems have different features, default settings, etc, which can cause little problems.

MX60/N and MX61/N with . . .

Lenz "DIGITAL plus", Software version 2.0 or higher :

This system is able to use "direct programming" of configuration variables; so all CVs can be used (read and write access). However, CVs # 49 - 54 has no meaning outside of ZIMO systems ("signal controlled speed influence").

The Lenz cabs (handhelds) are able to control decoders with 14 or 28 speed steps, but the default setting is 14 steps. ZIMO decoders are set to 28 speed steps by default. If this conflict remains unchanged, the headlights will not work (while speed control itself still works) !!!

To make headlights working correctly ***the system must be set to 28 speed steps*** for the addresses, where ZIMO decoders are used (see Lenz manual how to do this).

Of course it also would be possible to set ZIMO decoders for 14 speed steps (CV # 29, Bit 1), but normally it does not make sens to deteriorate the operation artificially.

Lenz "DIGITAL plus", Software version lower than 2.0 :

Only configuration variables # 1 - 4 and 29 (to be accesed by "5") can be programmed by the "old" Lenz system. If you want to change other CVs of the decoder, you must do it on a ZIMO system or on a modern Lenz system (2.0 or higher).

The "old" Lenz system works with 14 speed steps only. So the decoders must be configured to 14 speed steps, too: CV # 29, Bit 1 set to "0" (zero).

ROCO "digital is cool" :

Only the loco address can be programmed by the "loco mouse". Programming of configuration variables must be done on an other system.

The Roco system works with 14 speed steps only. So the decoders must be configured to 14 speed steps, too: CV # 29, Bit 1 set to "0" (zero).

Headlights are accessesd by the left mouse button, the third function output is accessed by the right mouse button.

DIGITRAX Chief :

Normally there are no problems at all !

The default settings for speed steps (28 and 128 active) are equal. But if headlights are not working correctly, the setting of speed steps should be checked both at the system and on the decoder (CV # 29, Bit 1 should be "1").

ZIMO decoders can be programmed both in "direct mode" and in "paged mode"; therefore programming by WINLOK (which works in the "paged mode" only) is possible, too. Programming on the main ("long form") can be used as well.